THURSDAY, OCTOBER 9, 1879

EDUCATION

Education, its Principles and Practice, as Developed by George Combe, Author of "*The Constitution of Man.*" Collated and Edited by William Jolly, H.M. Inspector of Schools. (London: Macmillan and Co., 1879.)

THIS book appears at an opportune moment. Inquiries into the philosophy of education are attracting increased attention among teachers, and the universities are taking measures with a view to bring to light the best rules for school teaching, and the principles which underlie those rules. In these circumstances, the laborious editor of this volume has done a public service, in placing on permanent record and in a modern form, the principal writings of one of the most original thinkers and earnest workers in the department of educational reform. But for such an enterprise, the speculations of Combe, many of which originally appeared in a fugitive form, or in books which are now well-nigh forgotten, would have remained unknown to the present generation; although some at least of his teaching is as much needed now as half a century ago, when it first appeared.

George Combe was born in 1788, and the seventy years of his life coincided with the period in which the national conscience became awakened to the necessity for public instruction; and in which occurred the principal experiments and controversies that have slowly shaped our present national system. His attention was very early directed to the defects, both in the supply of means for education and in the character and quality of such education as was then accessible to the people. A large part of his life was devoted to the exposition and propagation of his views on these subjects. Those views may be thus briefly summarised:—(1) A true science of education should be based on a knowledge of physiology and of mental philosophy. (2) School teaching should be mainly directed to the training of faculties, with special reference to the actual pursuits and duties of life. (3) Hence the study of our own physical constitution, of the phenomena of nature, and of the economic and social laws which govern the happiness of communities, ought to supersede many of the subjects included in the ordinary school routine, much of which he regarded as mere verbiage and as very sterile of intellectual result. (4) While increased attention ought to be given in schools to ethics and religion, in so far as they are deducible from the laws of our own well-being and that of society, the public school ought not to concern itself with dogmatic theology in any form. (5) Special efforts ought to be made to train girls, both to a stronger interest in intellectual pursuits, and to a better understanding of the laws of health and the right way of training young children. (6) A true knowledge of the science of mind for the purposes of education is to be obtained only through phrenology; and the study of this subject is not only indispensable to the teacher and the parent, as the guide to right training; but should also be introduced into the curriculum of the school itself.

These cardinal doctrines were set forth by Combe in his larger works on Phrenology, and on the Constitution of Man; in numerous pamphlets and contributions to periodicals; as well as in lectures delivered in many places, both in England and America. His writings are characterised by clearness, and by considerable wealth and variety of illustration; and by the unadorned and forcible style which comes rather from strong conviction and definite purpose than from conscious literary effort.

To bring together from many books, tracts, and reports of lectures a coherent statement of Combe's teaching was a difficult task. And in one respect his present editor has succeeded. Mr. Jolly is in full sympathy with his author, and has diligently studied his writings. He has acquainted himself with the collateral history of the chief movements in which Combe took part, and has brought down the record both of his achievements and of their results to the latest period. As one of the most energetic and thoughtful of Her Majesty's Inspectors of Schools, and as a careful student both of the history and of the philosophy of the pedagogic art, Mr. Jolly possesses some exceptional qualifications for the task he has undertaken.

Yet, although the book is complete and exhaustive, and is logically arranged, it cannot be said to have been skilfully or artistically edited. Combe's life was spent in a sort of missionary work, in expounding and enforcing to very different audiences, and with varied illustrations, a few principles which he held to be of paramount importance. It was inevitable that he should repeat what was substantially the same thing many times. One might have expected that an editor would select from the voluminous material before him the most effective statement of each of Combe's doctrines, and present them in a concise form likely to attract a modern reader. But Mr. Jolly has preferred to bring together lengthy extracts, and to produce a huge amorphous volume of 800 pages, with manifold reiteration of the same facts and speculations in every variety of form. The book is filled with cross-references, and furnishes quite a curious study of the mode in which a limited number of ideas and facts admit of being stated and restated, combined and recombined, looked at from all sides, and made to occupy the maximum of space. All Mr. Jolly's reminiscences and illustrations seem to revolve round the three or four eminent men, who have more or less adopted Combe's views, and the little group of secular schools—of which it seems that very few now survive—in which those views were most fully carried out. And the repeated reference to the same names becomes after a time not a little wearisome even to the most patient and sympathetic reader.

The book will enable this generation to estimate with tolerable accuracy Combe's true place in the history of education. On the need of scientific instruction, and of training the observant and reasoning powers by the study of natural phenomena, his teaching was much in advance of his own age. His vindication of the importance of some acquaintance with the structure and functions of our own bodies, and with the constitution of man and of society; and especially his demand that the laws affecting wages and capital, and the conditions of industrial success should be taught to children are sound and far-seeing and even now await fuller public recognition. The scant acceptance these doctrines have received from the promoters of public education is largely owing to the use of the word "secular" in connection with Combe and his

favourite schools, and to the unfortunate associations which have happened to cluster round that word. But Combe was an earnestly religious man, and in his view both natural and revealed religion were vital parts of education. He wished, it is true, to exclude controversial theology from the common school; but he strongly advocated the teaching of the Christian faith by clergy and parents at other than school hours. And in the school itself he thought that moral training—the cultivation of benevolence, reverence, and truthfulness—was indispensable. There is no one point on which his theories have been so much misunderstood. He believed that very noble incentives to duty and valuable helps in the formation of character were to be obtained from the wise study of the laws of our own being, and the structure of human society; and his chapter on "Moral and Religious Training through Science"—one of the most original and valuable in the book—is full of wise suggestions and of interesting examples. "The Ten Commandments," he would say, "are as clearly inscribed in the nature and constitution of man as on the tables of stone delivered to Moses." To him the revelations of Divine will and of the nature of human responsibility conveyed to us in science and in the order of nature were as sacred as the teachings of religion, were indeed a substantial part of religion itself. It must be owned that this is a doctrine which has not met with universal acceptance, and the exposition of which in Combe's writings is yet deserving of study. And in like manner his views on the training of children for the duties of citizenship, on a more rational system of teaching for girls, and on the necessity for instructing the teachers of the people in the art and mystery of their profession, were generally right and often profound; and possess hardly less value for this generation than for his own.

Yet it must be admitted that although Combe saw clearly and expounded forcibly some useful truths, he was not distinguished by much breadth of vision; and he certainly did not excogitate a full or philosophical system of education. He believed it possible by pure deduction to evolve a practical scheme from certain scientific principles; and there is evidence throughout the whole of his writings that he attached too little value to the lessons of actual experience, and that a fuller knowledge of child-nature, and of the practical working of schools would have rectified many of the deductions to which he attached most importance. He habitually depreciates the study of language, and repeatedly contrasts what he calls "real" knowledge with linguistic study, to the disparagement of the latter. To him words were mere means of expression and of communication. He never recognised the truth that words are the instruments as well as the representatives of thought; and that the right study of words and their relations is a discipline in logic and one of the most effective means of widening the range of a pupil's intelligence. Nor in his scheme of study was there much room left for history, for poetry, or for literary culture in any form. "*Res, non verba, quæso,*" was his favourite motto; yet it is not too much to say that his conception both of things and of words and of the part they should play in education was inadequate and unsound. And as to his system of phrenology, which he had learned from Spurzheim, and from which he hoped so much as an instrument for the regeneration of society, we must admit that it is now universally discredited by men of science; and that it betrayed Combe into a false method of psychological analysis. He believed that every separate moral propensity or mental gift had its own *habitat* in the brain, and was capable of being separately handled and developed. He thought that it would be enough to show a child that he was deficient, *e.g.*, in the organ of veneration, and then to set him to cultivate that faculty by placing before him appropriate objects for its exercise, and so to restore the balance of his character. Experience however has not confirmed this theory. It may well be doubted whether character has ever been fashioned in this conscious and mechanical way. At all events it does not appear even in this book, that the theory has ever been seriously carried out in practice; or that any one even of Combe's most enthusiastic disciples has accepted it as a working hypothesis, or applied it with success in the government, either of a school or of a home. There can be little doubt that Combe's faith in what he called phrenological science and his constant use of its terminology, vitiated many of his speculations about teaching, and prevented him from arriving at a full or satisfactory solution of the problem he desired to solve.

Few persons are better qualified than the editor of this volume to aid the public in discriminating what is ephemeral and obsolete in Combe's teaching from that which is likely to possess permanent value. This task, however, Mr. Jolly has not achieved and has scarcely attempted. And even those who most appreciate the importance of Combe's contributions to educational science will be fain to own that the bulk of this book is seriously disproportioned to the worth of its contents; and that a more valuable boon to the teacher's profession, and a far worthier and more enduring memorial of Combe himself might easily have been comprised in a volume of one-third of its size.

THE CAPERCAILLIE IN SCOTLAND

The Capercaillie in Scotland. By J. A. Harvie-Brown, F.Z.S., Member of the British Ornithologist's Union. (Edinburgh: David Douglas, 1879.)

THE introduction of birds into countries far from their original homes and their successful "acclimatisation" therein—to use a word now generally in vogue—is well known to have been accomplished in many instances—not always, however, to lead to the benefits expected to result from it. Thus the European house-sparrow has been transplanted to the United States of America, and is now a familiar bird of many of the great cities of the New World; the Indian grakle is at present one of the commonest birds in Mauritius, and in some of the Hawaiian Islands the native birds are said to have almost entirely disappeared in the course of their struggles for life with introduced species. But the *re*-introduction of a bird into a country where it has formerly flourished and where it has only recently—almost within the memory of man—become extinct, is, so far as we know, almost an unparalleled fact, and one that is well worthy of an accurate record.

Such has been the case in our own islands with one of the finest and largest species of game birds commonly

known as the capercaillie, or cock of the woods—the *Tetrao urogallus* of naturalists—and Mr. Harvie-Brown tells us the story of its extinction and revival in the interesting volume now before us.

The capercaillie, as Mr. Harvie-Brown after much discussion, decides that the name is most correctly written, was certainly a not unfrequent denizen of the pine-woods of Scotland and Ireland in former days, but, for some not yet clearly understood reasons, became gradually rarer in both countries, and according to the best evidence was finally extinct between the years 1745 and 1760, although there are several records of its alleged occurrence in Scotland at a later date, which Mr. Harvie-Brown considers "at least worthy of notice." In 1807 a capercaillie is said to have been shot in the Camus-na-gaul woods opposite Fort William, but this must have been the last survivor of the ancient race, for it is allowed on all sides that at the beginning of the present century the capercaillie could no longer be reckoned as an existing "British bird." Its reintroduction was effected by the late Marquis of Breadalbane in 1837 and 1838, after several ineffectual attempts. Living birds obtained in Sweden through the instrumentality of Sir Thomas Fowell Buxton and by the energy of Mr. Lloyd, the well-known Swedish sportsman and naturalist, were transported to this country and safely delivered at Taymouth under the care of English gamekeepers. About forty-eight individuals were imported in these two years, some of which were turned out, while others were kept in captivity for breeding purposes. So well did they succeed that in 1862 or 1863 their numbers on the Breadalbane estates were estimated to be at least 1,000, whilst according to other accounts they reached at this period to over 2,000 in number. From the Taymouth woods the capercaillies spread gradually over the adjacent districts of Central Scotland, wherever fir-woods prevailed suitable to the habits and food of the bird. Mr. Harvie-Brown gives us details of their first appearance and present numbers on various estates in Perthshire, Forfarshire, Fife, Kinross, Clackmannan, and Stirling, besides other outlying counties. A neatly executed map enables us to realise at one glance the statistics that Mr. Harvie-Brown has so diligently collected. "The capercaillie then," he concludes, "has populated the woods and forests of part of Scotland principally by its own exertions, since the great restoration at Taymouth; but there are certain minor centres of introduction which have undoubtedly added *some* impulse to their advance, though perhaps not to any extent compared with the impulse from the great centre." All naturalists must, we are sure, feel indebted to Mr. Harvie-Brown for the pains he has taken in investigating this interesting subject, and will congratulate themselves upon the restoration of this noble species to the British avifauna.

OUR BOOK SHELF

San Remo and the Western Riviera, Climatically and Medically Considered. By Arthur Hill Hassall, M.D. (London: Longmans and Co., 1879.)

DR. HASSALL has written a really useful work on a part of the Italian coast possessing many points of interest, more especially to those affected with chest diseases. He himself has spent two winters in the Western Riviera, and during that period has diligently collected information by personal observation and otherwise on the spot. Partly in this way, and partly by consulting anthorities on the topography of the district, and with the help of specialists in various departments of natural history, Dr. Hassall has compiled a work which may be taken as a full and trustworthy guide by all who wish to visit the Riviera either for pleasure or health. There are a few attractive illustrations and a good map.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.*]

An Index to Zoological Genera

THE Smithsonian Institution at Washington will publish at an early day an index, in one alphabet, to all genera hitherto proposed in zoology, whether for recent or fossil animals. It is to be based upon the "Nomenclators" of Agassiz and Marschall and the indexes to the *Zoological Record.* The name of the genus will be followed by the name of its proposer, the order to which it is referred, the date of its publication, and the symbols **A.**, **M.**, **Z.**, or **App.** (to indicate that a full reference may be found in [**A.**] Agassiz's "Nomenclator," [**M.**] Marschall's "Nomenclator," [**Z.**] the *Zoological Record*, or [**App.**] the Appendix to the proposed work), thus:—

Donachlora, *Sodoffsky*, Mamm., 1837, **A.**
Dorcasia, *Gray*, Gaster., 1847, **M.**
Loganius, *Chapuis*, Coleopt., 1869, **Z.**
Periplacis, *Geyer*, Lepid., 1837, **App.**

Names to which objection has been raised will be prefixed by an asterisk.

The appendix referred to will record in greater detail names which have been overlooked in the lists above mentioned, or have been published since 1877, the year reviewed in the last *Zoological Record*.

The object of this communication is to invite *at once* from European zoologists, and especially from palæontologists, lists of such names as should appear in the appendix. Such names (including corrections of any kind to the text of Agassiz's or Marschall's Nomenclators) should be accompanied by the name of the proposer of the genus, full bibliographical reference, date, etymology, and the order of animals to which the genus is referable. *In the Index the name of the person furnishing the reference will also be added as its sponsor.*

Many American zoologists have promised their assistance, but it must be evident that a work so extensive and of such universal value can only be satisfactorily prepared by the aid of European naturalists. As it is expected that the MS. of the Index will be ready by December 1 next, friends of the plan are earnestly invited to communicate with the subscriber at the earliest possible day.

SAMUEL H. SCUDDER

Library of Harvard University, Cambridge,
U.S.A., September 22

The Mineral Waters of Hungary

THE numerous mineral waters of Hungary, some of which are used as table-waters, while others are prized for their medicinal properties, are unfortunately very imperfectly known either to the scientific world or the general public, and, what is worse, many of the particulars which have been published about them are altogether incorrect and misleading.

There are a number of balneological works treating of the European mineral springs generally, which include descriptions of those of Hungary, but in almost all cases these descriptions are either obsolete or unreliable. That such incorrect statements should appear in the works of foreigners is perhaps excusable, when we consider the difficulties under which the authors must labour in seeking to obtain information upon the subject; but we may fairly expect that a work published in Hungary should be without any such serious errors. It is a most unfortunate

circumstance that a work bearing the title "Les Eaux Minerales de la Hongrie," published under the auspices of the Hungarian Commission of the last Paris Exhibition, and very extensively circulated by them, is found upon examination to be altogether unreliable in its information. In the interests of truth I feel called upon to point out to foreigners the unsatisfactory nature of this work. This condemnation of the work in question is borne out by the following facts:—The book enumerates less than forty per cent. of the localities in Hungary at which mineral springs occur, no fewer than a thousand of such localities being omitted. Perhaps it is by way of compensating for these omissions that the anonymous author augments his list by making two or three mineral springs out of one by not discriminating its synonyms, and also by enumerating others which have no real existence. In many cases the author has failed to indicate the localities to which his information refers, especially in those instances in which there are several places of the same name; and these difficulties are increased by the numerous typographical errors in the book. The analyses published in the work are of a very unsatisfactory character, for while more than one hundred of the most recent and valuable analyses are altogether omitted, others, which were made twenty or thirty years ago, and are therefore far less reliable, are included in it.

Although it cannot be expected that a large class of readers should take an interest in these details about the Hungarian mineral waters, yet I have thought it right to point out the unreliable character of this work in your widely-circulated journal, so that the errors should not be transferred to the pages of balneological works of a more general character. To the authors of such works I should be glad to furnish information concerning the mineral waters of this country, as it is a subject which I have made my especial study. J. BERNÁTH

Buda-Pest

Does Sargassum Vegetate in the Open Sea?

IT is related by Humboldt and Harvey that floating *Sargassum bacciferum* vegetates in the open sea, by sprouting branches without fructification, whilst other naturalists have seen in the yellowish floating pieces only the pale and altered dead remains of the plant. If these floating fragments were capable of vegetating, their branches should be brown or olive-coloured like living specimens on the rocks below water on the sea-shore, and if floating Sargassum really grow, fructification should not be wanting.

I have heard from several travellers, who have sometimes crossed the Sargasso Sea, that they, like me, never saw other than pale and dead floating sargassum, so that I believe those accounts of Humboldt and Harvey to be erroneous. Does any reader of NATURE know of living Sargassum in the open sea as a fact?

There exist many fanciful reports on Sargassum, *e.g.*, that some branches of the floating Sargassum rise two inches above water, and are thus driven along by the wind. Can any one confirm this? No botanist has hitherto observed it, and no sea-weed is known to behave thus. Haeckel and other learned men who never crossed the Sargasso Sea, speak of "a colossal sea-weed forest of 40,000 geographical square miles."

I would be greatly indebted for exact information as to the degree of density in which Sargassum has been observed. Although I was eleven days crossing in a steamer the two great seas containing Sargassum, I saw nothing at all in the Pacific on the direct route from San Francisco to Yokohama; and in the Atlantic I observed only single fragments from 50 to 100 feet apart; other credible travellers assure me of having seen the Sargassum sometimes almost grouped together in loose masses or strips of about 400 feet in length, hardly at all entangled and of no depth. I doubt therefore, also, whether Sargassum could hinder sailing vessels. OTTO KUNTZE

Leipzig-Eutritzsch, September 30

[In Dr. Kuntze's letter, vol. xx. p. 426, line 4, read: "In Eozöon they became;" line 31, "under red heat;" line 40, condensed, not into incandescent liquids, but into incandescent crystals; line 44, "granate" ("garnet," not "granite").]

A Liquid Rheostat

WHILE experimenting on resistance to the electric current, I have devised an instrument in which fluid is used to conduct the current under examination. This may perhaps be of use to some who are interested in this subject. The sketch, Fig. 1, shows the nature of the instrument. A B is a piece of elastic tube containing a weak solution of salt in water; this is held in the clamp C. By the screw D the tube can be compressed and its sectional area altered, and through this its resistance. G is the galvanometer and E the battery. Finding the instrument to

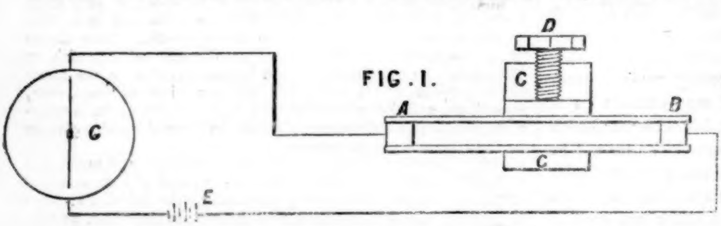

FIG. 1.

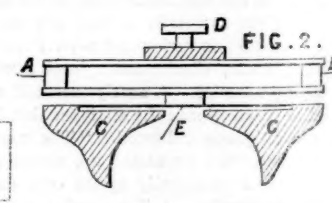

FIG. 2.

be very sensitive on a reflecting galvanometer I thought that probably the tube would be a means of transmitting articulate speech. I find this to be the case. Fig. 2, A B, elastic tube similar to the one used in the former instrument; C C, mouthpiece; E, disk, connected to the tube at E. A B is put in circuit with a telephone and battery; D, screw to regulate the pressure on the tube. I call the instrument, Fig. 1, a liquid rheostat.

Taunton, September 24 FREDERICK JOHN SMITH

The Carving of Valleys

MR. WALTER R. BROWNE tells us in NATURE, vol. xx. p. 504, that he has discovered in the valley of a highland burn evidence that "the agencies of 'sub-aërial waste' are seen to have worked their will for untold ages on the Cambrian sandstones of Glen Beansdale, and to have produced—nothing."

Without making any attempt to explain how the old river channel he describes is not "choked by the *débris* which has come down from its sides," further than to suggest that "the tiny runnel which now drains the gulley" may sometimes be, not the little streamlet which Mr. Browne saw, but a great soaring torrent quite capable of "direct erosion of its own, and of sweeping away the *débris*" which may have tumbled into it from its sides, it appears to me remarkable that evidence *against* sub-aërial denudation should be brought from the Scottish highlands where every mountain and valley seem to testify eloquently in its favour. I am pretty familiar with a great part of the northern highlands, and I do not remember a single mountain which does not bear on its flanks ample evidence of the energy of this form of erosion. It is now some years since I have been at Loch Maree, but if I am not greatly mistaken Ben Slioch itself is draped in loose angular fragments, the result of its own decay. If Mr. Browne, while in these regions, visited Glen Sligachan, in Skye, he must have found that wherever he walked in that wild valley, it was on fragments of rock that have not only slid down the mountain sides in vast torrents, but spread out over the whole floor of the glen, burying the original glaciated surface deep beneath them; and in all parts of the more southern and central highlands we find the same irresistible evidence of the continued waste of the hillsides by heat and cold and the rainfall.

As to the behaviour of streams in excavating valleys, very much depends upon the character and arrangement of the rocks over which the river flows; there are many streams in both

highlands and lowlands which in one part of their course have cut deep vertical gorges not unlike cañons, while at another they have scooped out wide open valleys with gently sloping sides, so to come to any conclusion based on the assumption that the eroding action of streams is uniform is very unsafe.

Mr. Browne seems also to take a very peculiar view of the extent of the ancient glaciers, as he speaks of the channel of the little stream he describes as "sufficient to guide the glacier in its flow," seeing that the great glacier which flowed over Scotland from north-west to south-east took no notice of such a channel in its course as the Firth of Tay, but swept over it and the county of Fife beyond, scarcely showing a trace of being deflected at all. Surely there could not be such an enormous difference in the dimensions of the glaciers on the opposite coast as this would indicate. Whatever was the case on Loch Maree, the glaciers that moved down Loch Assynt and Loch Broom were no pigmies. JAS. DURHAM

Newport, Fife, September 27

The Bis-cobra, the Goh-sámp, and the Scorpion

SNAKES of all kinds are held in great horror by the natives of India, and they slay indiscriminately and ruthlessly all they come across, but this horror pales before the terror inspired even by the names of the bis-cobra and goh-sámp,—terror so great, that, if met with, the harmless animals are given the widest berth possible, and their destruction is never attempted. Though actual animals, they are virtually mythical, that is as regards the deadly properties assigned to them, and we easily recognise in them the originals of the flame-breathing dragon and deadly basilisk. The gaze of the bis-cobra is awful even from a distance and its bite is instant death; and if the goh-sámp breathes upon, or at you, you fall dead at once.

With such awful reputations attached to them, I lost no time, in my early career, in attempting to make the acquaintance of these formidable reptiles, and, after much labour, succeeded.

No one would help me in procuring a bis-cobra, and my servants repeatedly warned me against the risk and madness of the attempt. At one time I had engaged the services of a savage woodsman in collecting birds' eggs, and to him I, one day, applied for a bis-cobra, but he at first refused, and it was only the promise of large bakhsheesh that ultimately induced him to promise his assistance. After several days he appeared carrying an earthen pot at the end of a long bamboo, and meeting me, whispered mysteriously in my ear "Sahib! bis-cobra!" Glad of the news, I summoned my servants, who, when they heard the reason of the summons, reluctantly formed a distant semicircle. The pásee cautiously put down the pot and also retired to a distance. In no way dismayed, I approached the pot, removed the dirty rag around its mouth and looked in. As expected, I found a beautiful brown and yellow lizard, freely protruding in its fear a forked anguine tongue, and anxious to escape. On taking it up it seized my hand with its delicate teeth, and in this position I held it up to the horror-stricken servants who exclaimed in fear "Sahib! sahib! chōr do, pheak do (Master! master! let (it) go, throw (it) away)." Then, on my declining to do either, they, like the barbarians of old, waited anxiously to see whether I "should have swollen or fallen down dead suddenly," and, seeing no harm, they quietly dispersed.

My adventure with the goh-sámp was unsought and equally satisfactory.

Walking in my garden one day, I met the gardener running away with affrighted look from a pear tree, and asked the reason; he could only gasp out "Goh-sámp, sahib, goh-sámp!" and implore my return. Delighted at the opportunity, I pressed on, and soon saw the awful reptile trying to dodge my gaze; a large scaly, uncanny looking tree lizard about fourteen inches long. In the distance the mali (gardener) implored me to beware his "phoonk" (blast of breath), but I courted it, by trying to dislodge him, which I succeeded in doing by shaking the bough, and then he threw himself on the ground and scuttled up another tree. Both lizards are absolutely harmless, and I believe a poisonous lizard is quite unknown.

The scorpion is not dreaded like the snake, but, like it, is inevitably killed. Its habits and pursuits well deserve study; my observance of the former has enabled me to clear away (to my own satisfaction) many obscurities with regard to its poison weapon and the mode of using it. And let me declare at once that the popular idea regarding scorpionic suicide is a delusion based on impossibility. Owing to the position and nature of its weapon, the animal cannot strike itself. It does not protrude a sting as bees, *et hoc genus omne*, do, and the line of strike is downwards and backwards, with at times a lateral but yet downward motion. As literally described in Holy Writ, *it strikes but does not sting;* and its motion in so doing may be imitated by seizing the tip of the index or middle finger with the thumb, and suddenly liberating the former.

The poison is acid and albuminous; the latter I presume, as on placing a living specimen in spirit, the animal in its death throes ejected it, and it immediately coagulated in threads.

The pain and constitutional disturbance attendant on scorpion strike are often very severe, and children have occasionally succumbed; but adults only complain of the pain, which generally passes off in half-an-hour. On two occasions I have passed through a host of migrating crickets, once by day and once by night; on the first occasion my carriage wheels crunched for a mile through a cricket migration; and on the second my palkee bearers' feet slid about amid crushed crickets; on this occasion one of the bearers yelled out that a scorpion (out on a cricket spree) had struck his foot, and hobbled up to the palkee. Having the means at hand I applied a paste of ipecacuanha and laudanum, with almost immediate relief, and the bearer trudged on with the rest.

Peshawar H. F. HUTCHINSON

Certain Animal Poisons

I HAVE had unpleasant experiences of the poisonous properties of the Portuguese man-of-war, the great hornet, and the centipede.

While bathing at the Cape as a boy I managed to get the long lovely blue tentacle of the first round my wrist, and well recollect the attendant long-enduring agony and irritation, while the blue mark remained long on my wrist. Twenty-five years after, while soaking in a P. and O. steamer's marble bath in Madras roads, I suddenly received what seemed an agonizing stab below my left knee, and jumped out of the bath with the pain. The cause was at once apparent, a bit of the fatal blue filament had been pumped into the bath, and left the familiar mark on my knee, and I bore it for a long time.

On one occasion I was showing some friends over the famous "Arrah House" and opened a small window to let in more air and light; in doing so, I unwittingly disturbed the adhesions of a great hornet's nest, and one of the infuriated inmates at once stung me on the left temple; the pain was intense and the swelling immediate; aware of the constitutional disturbance which would follow, I made for home (about 500 yards distant), and reached the threshold of my drawing room, and there I was brought to an instant standstill, unable to move hand or foot, and trembling like an aspen leaf. I was laid on a sofa, and asked for a glass of port wine, which soon revived me.

This dreadful hornet, nearly two inches long, deep brown with a broad yellow band across the abdomen, builds large globular paper nests, and is not rare in the Himalayas, where it may often be seen in the pines. The hillmen dread it extremely, and with good reason, for a swarm, or even a few individuals will attack you fiercely and follow you for miles.

Griffs, who have fired at a nest, against the remonstrances of their hillmen, have paid dearly for their rashness. When attacked, the hillmen squat down and drawing their blankets closely around them, await the subsidence of the storm, rarely escaping two or three stings. I have known *one* of these hornets kill a child by its sting; and many horses have been destroyed by an infuriated swarm. These are the dreadful animals which assisted in the expulsion of the Amorites of old.

The common bee, which in India often builds in trees and ruins, frequently attacks men and horses, irritated by the smoke of the fires (for cooking) lighted under the trees or in the buildings, and a general *sauve qui peut* is the only mode of escape.

Many ludicrous adventures occur from this cause out here, and I will describe a recent one. The officers of a British regiment stationed at Umballa were dressing for Sunday morning Church parade, when the alarm was given in the compound of three who lived together, that the bees were abroad. As escape from the parade was impossible, and the infuriated bees had to be faced, the three griffs made a syce (horse attendant) envelope himself in a blanket, while each wrapped a sheet around himself, and then formed a line, the front officer holding on to the syce's bamboo, and the other two to one another's swords, and in this guise they groped their way out of the compound surrounded by

the angry bees; cautiously emerging from their sheets on the high road, the first person they encountered was their Colonel and his family driving to Church. The finale may be imagined!

I have always been fond of sleeping out during the hot weather, *sub Jove frigido*, or rather *torrido*, and used to have a sooráee (a porous earthen water bottle) capped by a tumbler, on the ground by my side.

One night I awoke to drink and, half awake, lifting the sooráee on to my naked knee proceeded to fill the tumbler. In a moment I felt as if a red hot poker had been freely applied to my knee, and, thinking that I had been stung by a snake, rushed into the house for a light, and a dose of sal volatile. I was now wide awake, and returned with the light to examine into matters, and then I found a large centipede coiled round the bottom of the sooráee, whither it had come for coolness or a drink, or both. It was six inches long. Judging from the size of the burn (for I bore the large red mark for many days), I inferred that I had not been bitten, but that the whole animal was acrid.

Peshawar H. F. HUTCHINSON

Spider's Web, New Caledonia

CONSUL LAYARD's account of the spiders' webs of the Polynesian Arachnids (NATURE, vol. xx. p. 456) reminds one of the colonial enthusiasm of certain fair ladies in Mauritius seventy years ago, previous to the capture of that island by General Abercrombie.

Throughout the Mascarene group are numerous species of *Araneidæ*, among which *Epeira inaurata* and *E. mauricia* are pre-eminent, their bright yellow webs being conspicuously stretched between the pointed leaves of the agaves and prickly-pears. Taking advantage of these "grandes toiles verticales à fils jaunes, soyeux et susceptibles d'être travaillés; sous le gouverneur-général Decaen, les dames créoles de l'île de France tissèrent avec les fils de ces belles aranéides une paire de gants dont elles firent hommage à l'impératrice." S. P. OLIVER

October 5

Change of Colour in Frogs

CAN any of your readers tell me if it is a fact that frogs change their colour before a change takes place in the weather?

A few days ago I was told at a village in Worcestershire, during heavy rain, that it would be fine to-morrow because a frog had been seen turning yellow. The fine weather came. I was informed that frogs become dark-coloured before wet weather sets in. W. J. CHAMBERLAYNE

Junior United Service Club, September 30

["The changes which the colour of the frog undergoes both in intensity and hue from the *variation of temperature, the presence and absence of light* . . . although certainly much less striking and considerable, are *scarcely less varied* than those exhibited by the chameleon."—Bell, "British Reptiles."]

SUBJECT-INDEXES TO TRANSACTIONS OF LEARNED SOCIETIES[1]

WE all remember the excellent paper read at the Oxford Conference by Mr. J. B. Bailey, sub-librarian at the Radcliffe Library, upon the advantage of a subject-index to scientific periodicals. Mr. Bailey spoke with just praise of the splendid alphabetical catalogue issued by the Royal Society, but observed that from the nature of the case this is "nearly useless in making a bibliography of any given subject, unless one is familiar with the names of all the authors who have written thereon." This is manifestly the case. As an illustration both of the value and the deficiencies of the Royal Society's index, I may mention that while on the one hand it has enabled me to discover that my father, chiefly celebrated as a philologist, has written a paper on the curious and perplexing subject of the formation of ice at the bottoms of rivers, the existence of which was wholly unknown to his family, it does not, on the other hand, assist me to ascertain, without a most tedious search, what other writers may have investigated the subject, or consequently how far his observations are in accordance with theirs. Multiply my little embarrassment by several hundred thousand, and you will have some idea of the amount of ignorance which the classified index suggested by Mr. Bailey would enlighten. We may well believe that the only objection he has heard alleged is the magnitude of the undertaking, and must sympathise with his conviction that, granting this, it still ought not to be put aside merely because it is difficult. I hope to point out, however, that so far as concerns the scientific papers, to which alone Mr. Bailey's proposal relates, the difficulty has been over-estimated, that the literary compilation need encounter no serious obstacle, and that the foundation might be laid in a short time by a single competent workman, such as Mr. Bailey himself. Of an index to literary papers I shall speak subsequently; and, there, I must acknowledge, the difficulties are much more formidable. But as regards scientific papers, it appears to me that the only considerable impediment is the financial. When the others are overcome, then, and not till then, we shall be in a favourable position for overcoming this also. The reason why the formation of a classified index to scientific papers is comparatively easy, is that the groundwork has been already provided by the alphabetical index of the Royal Society. We have the titles of all scientific papers from 1800 to 1865 before us, and shall soon have them to 1873. Though it might be interesting, it is not essential to go further back. We have now to consider how best to distribute this alphabetical series into a number of subject-indexes. To take the first step we merely require a little money (the first condition of success in most undertakings), and some leisure on the part of a gentleman competent to distinguish the grand primary divisions of scientific research from each other, and avoid the errors which cataloguers have been known to commit in classing the star-fish with constellations, and confusing Plato the philosopher with Plato a volcano in the moon. I need only say that very many of our body would bring far more than this necessary minimum of scientific knowledge to the task. I may instance Mr. Bailey himself. The money would be required to procure two copies of the alphabetical index (which, however, the Royal Society would very likely present), and to pay an assistant for cutting these two copies up into strips, each strip containing a single entry of a scientific paper, and pasting the same upon cardboard. It would be necessary to have two copies of the alphabetical catalogue, as this is printed on both sides of the paper; and as the name of the writer is not repeated at the head of each of his contributions, and would therefore have to be written on the card, close supervision would be required, or else a very intelligent workman. When this was done, the entire catalogue would exist upon cards, in a movable form instead of an immovable. The work of the arranger or arrangers would now begin. All that he or they would have to do would be to write somewhere upon the card, say in the left hand upper corner, the name of the broad scientific division, such as astronomy, meteorology, geology, to which the printed title pasted upon the card appertained, and to put each into a box appropriated to its special subject, preserving the alphabetical order of each division. We should then have the classed index already in the rough, at a very small relative expenditure of time, money, and labour. For the purposes of science, however, a more minute subdivision would be necessary. Here the functions of our Council would come into play, and it would have a great opportunity of demonstrating its usefulness as an organising body by inducing, whether by negotiation with individuals or with scientific corporations like the Royal Society, competent men of science to undertake the task of classifying the papers relating to

[1] By Richard Garnett, Superintendent of the Reading Room, British Museum. Read at the March monthly meeting of the Library Association of the United Kingdom. Contributed by the Author.

their own special studies. Men of science, we may be certain, are fully aware of the importance of the undertaking, which is indeed designed for their special benefit; and although they are a hard-worked race, I do not question that a sufficient number of volunteers would be forthcoming. When one looks, for example, at the immense labour of costly and unremunerated research undertaken by a man like the late Mr. Carrington, one cannot doubt that men will be found to undertake the humbler but scarcely less useful and infinitely less onerous task of making the discoveries of the Carringtons generally available. I am sure, for instance, that such men as Mr. Knobel and Mr. Carruthers would most readily undertake the classification of the astronomical and the botanical departments respectively, provided that their other engagements allowed, as to which, of course, I cannot affirm anything. Supposing our scientific editors found, they would proceed exactly in the same manner as the editor who had already accomplished the classification in the rough. Each would take the cards belonging to his own section, and would write opposite to the general subject title written by the first classifier the heading of the minor sub-section to which he thought it ought to be referred; thus, opposite Botany—Lichen, and so on. He would then put the title into the box or drawer belonging to its sub-section, and when the work was complete we should have the whole catalogue in a classified form, digested under a number of sub-headings. Some preliminary concert among the scientific editors would, no doubt, be necessary, and a final revision in conformity with settled rules. It might be questioned, for example, whether a dissertation on camphor properly belonged to botany, chemistry, or materia medica; whether the subject of the gymnotus was ichthyological, anatomical, or electrical; whether in such dubious cases a paper should be entered more than once. It would save time and trouble if these points could be determined before the classification in the rough was commenced; in any case considerable delay from unavoidable causes must be anticipated. It is to be remembered, on the other hand, that the work could, under no circumstances, be completed until the publication of the Royal Society's alphabetical index of papers from 1865 to 1873 was finished, which, I suppose, will not be the case for two or three years. There will, therefore, be sufficient time to meet unforeseen causes of delay. If the classified index could be ready shortly after the alphabetical, if we could show the world that the work was not merely talked about as desirable, but actually done in so far as depended upon ourselves and the representatives of science; that it already existed in the shape of a card catalogue, and needed nothing but money to be made accessible to everybody—then we should be in a very different position from that which we occupy at present. I cannot think that so much good work would be allowed to be lost. The catalogue, not being confined to papers in the English language, would be equally useful in every country where science is cultivated, and would find support all over the civilised world. Either from the Government, or from learned societies, or the universities, or the enterprise of publishers, or the interest of individual subscribers, or private munificence, means would, sooner or later, be forthcoming to bring the work out, and thus erect a most substantial monument to the utility of our Association. It would obviously be important to provide that scientific papers should be indexed not only for the past, but for the future. If, as I trust, the Royal Society intends to continue the publication of its alphabetical index from time to time, the compilers of the classified index will continue to enjoy the same facilities as at present. There must be some very effectual machinery at the Society for registering new scientific papers as they are published. What it is we may hope to learn from our colleague, its eminent librarian, who must be the most competent of all authorities on the subject. Mr. Bailey draws attention to several scientific periodicals as useful for bibliographical purposes, and I may mention one which seems to be very complete.[1] It is published at Rome. The number for last December, which I have just seen, is so complete that, among a very great number of scientific papers from all quarters, it records those on the telephone and the electric light, in the "Companion to the British Almanac," which, I think, had then been only announced here, not published, omitting the other contributions as non-scientific. It further gives a complete index to the contents of the *Revista Cientifica*, a Barcelona periodical, which had apparently just reached the editor, from its commencement in the preceding April. By this list I learn that the electric pen, the subject of our colleague Mr. Frost's recent paper, had been the theme of a communication to a Barcelona society in May last. It certainly seems as if any library that took this periodical in, and transcribed the entries in its bibliographical section on cards properly classed, would be able to keep up a pretty fair subject-index to scientific papers for the future. I must, in conclusion, say a few words on a subject-index to the transactions of literary societies. The prospect is here much more remote, from the want of the almost indispensable ground-work of a general alphabetical index. We have seen what an infinity of trouble in collecting, in cataloguing, and in transcribing will be saved by the Royal Society's list in the case of scientific papers, and are in a position to appreciate the impediments which must arise from the want of one in this instance. The work could be done by the British Museum if it had a proportionate addition to its staff, or by a continuance of the disinterested efforts which are now devoted to the continuation of Mr. Poole's index to periodicals. Failing these, the most practical suggestion appears to me Mr. Bailey's, that the undertaking might be to a considerable extent promoted by the respective societies themselves. If the secretaries of the more important of these bodies would cause the titles of the papers occurring in their transactions to be transcribed upon cards and deposited with this Association, we should accumulate a mass of material worth working upon, and which might be arranged while awaiting a favourable opportunitity for publication. In some instances even more might be done. The library of the Royal Asiatic Society, for example, contains not merely its own transactions, but those of every important society devoted to Oriental studies, as well as all similar periodicals. Our friend, Mr. Vaux, could probably, in process of time, not only procure transcripts of the papers contained in these collections, but could induce competent Orientalists to prepare a scheme of classification, and such a classified list, complete in itself and of no unwieldy magnitude, could be published as a sample and forerunner of the rest. The initiative in such proposals, as well as those referring to scientific papers, should be taken by our Association, which can negotiate with eminent men and learned bodies upon equal terms, and speak with effect where the voice of an individual would be lost. The desideratum of a classed index, in a word, affords our Society a great opportunity of distinguishing itself. It is this aspect of the matter, no less than the importance of the matter itself that has encouraged me to bring it under your notice.

ON VARIABLE STARS

IT had long been known that certain stars greatly varied in brightness and some observations had been made concerning them, but it was reserved to the Herschels to pave the way for practical investigators. Notwithstand-

[1] *Bulletino di bibliografia e di storia delle scienze matematiche e fisiche.* Pubbl. da B. Boncompagni; Rome, 1868, &c.

ing the importance of the results which the observation of them bids fair to offer concerning the nature of the sidereal universe, the variable stars have not attracted so much attention as other even less important phenomena in the starry heavens, and one cause of this must be sought in the circumstance, that most of these observations are best made with very small telescopes or even with the naked eye, and while it is the duty of the professional astronomer to make use of the expensive instruments, of which he has charge, the inclination of the amateur astronomer in this country often leads him in the same direction. However, the attention of those who take an interest in the science but cannot afford a large outlay, cannot too often be urged towards this kind of observation, that while it so much needs their help is so thoroughly within their reach.

The best method is due to Argelander, a follower of Bessel, who was considered the first authority on the subject during his lifetime. It was propounded in his "Aufforderung an Freunde der Astronomie zur Anstellung von eben so interessanten und nützlichen, als leicht auszuführenden Beobachtungen über mehrere wichtige Zweige der Himmelskunde," which appeared in Schumacher's *Jahrbuch für* 1844, a periodical seldom met with in this country, which may in a measure explain the comparatively little attention that has been given to this subject on the part of British amateurs, who have so energetically followed up more complicated investigations. The success of those who have spent even a short time on these observations may be considered a sufficient appeal, and we venture to hope that the following short sketch of the easiest and most convenient method will be acceptable to some of the readers of NATURE who have not Argelander's lengthy paper at hand. The observations are in reality far simpler than the description of them looks. The stars visible to the naked eye are arranged in six classes according to their brightness, but it is often doubtful to what magnitude we shall refer an object, because we are able to judge about much smaller differences than those that distinguish two magnitudes, the number of which is therefore too small. The smallest difference perceptible to the average sight is a tenth of a magnitude, and we are therefore able, by a method of sequences, to reach a considerable accuracy. Researches on variables have further this advantage that we do not want to know the absolute magnitude but only the brightness relatively to certain other stars. These comparison-stars must be chosen with intervals of not above a half magnitude, and be situated as near the variable as they can be had, for the transparency of the air is often different not only in different altitudes, but also in different azimuths—nay even owing to aqueous vapour and chemical causes at times in the same place. Observations near the horizon should be avoided, and near the zenith the position is difficult. Twilight, moonlight, and lamplight would likewise interfere, and above all it must be avoided to observe from a lighted room. Against the moon or a distant gas-lamp in a town a screen can be used. If clouds are near they will render the comparisons uncertain. Cirro-stratus commencing to descend from high in the atmosphere is particularly deceiving. The estimation of stars of the first magnitude is difficult, and an evenly illuminated background in this case rather an advantage, or a slight fog, but in the latter case and when detached clouds are on the sky the observations have to be repeated with an interval of a few minutes, because fogs are rather irregular; at other times an observation may be secured in a few minutes, and more observations the same night are only required in case of quickly changing stars. They generally give identical results, but two or more observers are an advantage, though their estimations may have constant differences, because various colours affect individual eyes differently. No attempt need be made to look simultaneously at both stars, because the sensibility of the eye in different spots is different, and this error would not be eliminated. Look first at one star, then turn quickly to the other, look at that and return to the first again. It is well to turn the eye a little to the side, when watching a star. It appears then brighter, because the middle of the retina is tired with constant work. The comparison of stars barely visible is to be avoided. The results, together with the nature of the circumstances, should be noted at once, and in the dark. It will be remarked that the causes of error, referred to above, are not sensibly removed by using photometers, and other errors may be introduced by such complicated apparatus. Faint stars may be observed through a binocular. The glass used should be colourless, always the same, and the distance between the eye-glasses carefully adjusted. It must be confessed that this kind of work cannot be carried out in places where the sky does often not clear for months, as in North-West Ireland; on the other hand the English climate seems favourable. It is often blue sky, if only partly, and no superior definition is required. At present this part of astronomy is mainly dependent upon the labours of Julius Schmidt, of Athens. Some knowledge of the constellations is necessary, and that may be gained from Argelander's or Heis's Uranometries. In case the research be extended to telescopic stars Argelander's large atlas should be procured. It is known that Pogson at Hartwell and Madras has made diagrams of stars round the variables, which would be very useful.

The differences are noted in "steps," each of which is equal to a tenth of a magnitude. If the comparisons are doubtful but most give one star, a, larger than another, b, it is said that a is one step above b : $a\,1\,b$. If at all times a seems larger than b, it is two steps above it : $a\,2\,b$. If the difference is remarked at a glance, a is three steps above b : $a\,3\,b$. Still greater difference is denoted $a\,4\,b$, which is occasionally used, though so great a difference cannot be estimated so exactly as a smaller one, the probable error of which is much below one step, so that it is preferable to give the comparisons in half steps. For exercise Argelander's comparison stars can be used from "Astronomische Beobachtungen auf der Sternwarte zu Bonn," vol. vii., 1869. The steps might not be exactly identical in all cases, but they ought not to deviate much. The variable should not only be compared with the greater and smaller star but also with the mean of them, which is very accurate. From each comparison follows then the brightness of the variable, and the average of these is taken first in the common manner, next allowing weights inversely proportional to the number of steps, and the means of the two is assumed as the definitive result. Of course this is more estimated than computed, and the two results agree generally.

From magnitudes thus obtained in a scale of steps the epochs of maxima and minima are next sought, from which follows the period, which is the principal element. When a sufficient number of periods are available it can be seen whether this is constant, and if not, one must try to find a formula which will give the length at any time. A good many periods are about 300 days, but many only a few days. The brightness in the two principal phases will generally be found irregular if the period be so. Some stars have more than two maxima and minima during the same period. Next we project on a paper ruled in squares the brightness of the variable with the time as abscissa, counted from the nearest preceding maximum and expressed in parts of the respective period. The curve drawn as nearly as possible through the points, whose weights may be indicated by circles round them, is called the light curve, and on that we can read off the brightness for any moment, but it is not always possible to treat the observations thus *en masse*; sometimes single periods have to be separately discussed, and indeed when it is great we can arrive at some results from a single

period, but if it is short many revolutions must be watched. These stars proceed more quickly from minimum to maximum than from maximum to minimum, and this is also the case with new stars. At last it is found that the colour is most monochromatic nearest the minimum. The brightness of the comparison stars is best obtained from their comparison with the variable and become therefore better known the more revolutions are watched. The final discussion will sometimes show that one or more of the comparison stars are variable themselves, for astronomers agree that there are many more variable stars in the sky than those contained in the catalogues.

As to the physical explanation of these phenomena we do not learn much from Argelander, who was one of the last champions of the old school. It is even said about him that he to the last stuck to Herschel's theory of the structure of the sun in spite of this being opposed to Newton's axioms, and framed, according to the now obsolete assumption, that every heavenly body ought somehow to furnish a comfortable abode for beings like ourselves. We can only comprehend unknown things from what is already known to us, and it is therefore rational to suppose variable stars analogous to our sun, whose lustre must vary with the extent of its spots. It is no doubt reserved to the spectroscope to settle the question, meantime we can only keep in view Hind's important remark that variable stars are often of a ruddy colour, and appear surrounded by nebulosity at their minimum. W. D.

COFFEE-LEAF DISEASE OF CEYLON AND SOUTHERN INDIA

1. *HISTORICAL REMARKS.*—During the last ten years, the coffee plantations of Ceylon and Southern India have had to contend with a disease which has seriously affected their productiveness and entailed a heavy loss upon the proprietors. This disease, *Hemileia vastatrix*, popularly known as the coffee-leaf disease, was first observed in May, 1869, on a few plants in Madulsima, a newly-opened coffee district in the south-west of Ceylon, bordering on the low country. In July following, two or three acres were attacked, and from that time the disease has gradually spread, till, in 1873 all, or nearly all, the estates in the island were attacked by it. On the appearance of the disease in 1869, the distinguished fungologist, the Rev. M. J. Berkeley, determined its true character, and described it in the *Gardener's Chronicle* for 1869 (p. 1,157, with woodcut). It was found to be a fungus allied to the moulds, and named *Hemileia vastatrix*, B. and Br. It was subsequently described in the *Journal* of the Linnean Society ("Botany," vol. xiv. p. 93, pl. 3, Fig. 10), and a short notice appeared in the *Quarterly Journal of Microscopical Science*, 1873, pp. 79-81. In 1876 Dr. M. C. Cooke described and figured the disease from Indian specimens in the India Museum Report, 1876, pp. 4-6. More recently the Rev. R. Abbay, who, during several years residence in Ceylon, made this disease an object of special study, gave a fuller description of it, with the results of his observations upon the germination of the spores and their growth under artificial cultivation, in the *Journal* of the Linnean Society, 1878 ("Botany," vol. xvii. pp. 173-184, pl. 13 and 14).

In his first notice of the disease the Rev. M. J. Berkeley speaks of it as a "minute fungus which has caused some consternation amongst the coffee planters of Ceylon in consequence of the rapid progress it seems to be making amongst the coffee plants." He further remarks: "It is not only quite new, but with difficulty referable to any recognised section of fungi. Indeed, it seems just intermediate between true mould and Uredos, allied on the one hand to *Trichobasis*, and on the other to *Rhinotrichum*. Though the fungus is developed from the parenchyma of the leaf, there is not any covering to the little heaps, such as is so obvious in *Uredo* and its immediate allies, while the mode of attachment reminds one of *Rhinotrichum*." At that time no other form of *Hemileia* was known, and it was supposed to stand alone as the only species, and to be indigenous to Ceylon. Since then, another species of *Hemileia*, viz., *H. canthii*, B. and Br., has been found on a Ceylon jungle tree, *Canthium campanulatum*,[1] and lately Dr. Cooke appears to have met with a third species from Southern Africa.

Writing in 1874, Dr. Thwaites, the distinguished Director of the Botanic Gardens, Ceylon, describes the *Hemeleia vastatrix* as "a parasitic growth within the coffee tree of a well-defined species of fungus, originated and reproduced by means of spores, easily distinguished from every other known fungus." "There can be no question," he continues, "that this fungus is communicated from coffee plant to coffee plant through the dissemination of its spores, and that these may be conveyed by the wind, or by streams of water, or by animals of any kind moving from place to place." Though at first it was believed that some elements of the fungus were present "in the growing tissues of the coffee plant in a *diffused form*," this view was afterwards abandoned, further microscopical investigations having proved that the disease was mainly external, and "that the coffee tree suffered rather from exhaustion than from the poisoning of its juices." During 1873 and 1874 investigations of an important character were carried on by Dr. Thwaites and the Rev. R. Abbay, which led them to the conclusion that when grown upon charcoal kept constantly moist, the orange-coloured spores representing the fruit of the disease, gave rise to filaments more or less branched. At the termination of the branches "*secondary spores* appear to have been produced in the form of radiating necklace-shaped strings of little spherical bodies of uniform size, closely resembling the fructification of an *Aspergillus*."

2. *Effects produced.*—The effects of the fungus upon the coffee trees would seem to be the gradual loss of vital energy caused by repeated destruction of the leaves. The tree after the first attack of the disease, which is often apparently the most severe, throws out fresh, healthy-looking leaves, and exhibits for a certain period the appearance of having perfectly recovered. These fresh leaves, however, after the expiration of a few months, exhibit the characteristic spotting, and are sooner or later covered, on the under side, by orange-coloured dust representing the spores of the disease, and, as in the previous attack, fall prematurely. These repeated attacks at length seriously affect the health of the tree, which, if old and ill-cultivated, becomes of little or no value as a crop-producer.

The rapidity with which the disease was propagated after its first appearance, may be realised from the fact that although it was noticed only in one locality in May, 1869, it quickly spread to the neighbouring coffee-districts, and especially among native coffee, till in 1873 it was spoken of "as being found in nearly all, if not all, the estates in the island." The disease appears to have been noticed in India in 1869 and 1870, almost simultaneously with its appearance in Ceylon.[2] In February, 1874, its presence was seriously felt in Tellicherry, and it appears to have spread generally through the Wynaad and Mysore districts, and its first effects were so severe that it threatened to give a considerable check to coffee enterprise in Southern India.[3] In 1876 the disease appeared in Sumatra, and this year it has been found in the plantations of Java and Bencoolen; there can be little doubt, therefore, that the *Hemileia* is destined to be a wide-spreading and prevalent enemy in all coffee-producing areas of the East Indies.

The effects of the leaf-disease upon the exportation of

1 "Enum. Plant. Zeylan. Rubiaceæ." p. 153.
2 Report of India Museum, M. C. Cooke, 1876.
3 *Gardener's Chronicle*, February, 1874.

coffee from Ceylon, may be very distinctly traced. In 1869-70, before the disease had appeared generally upon the coffee plantations, Ceylon exported 1,009,206 cwts. of coffee, consisting of 860,707 cwts. plantation coffee, and 148,499 cwts. native coffee. In 1876-77, when there were 52,000 more acres in bearing, the total exports were only 797,763 cwts., viz., 727,420 cwts. plantation coffee, and 80,343 cwts. native coffee.[1]

The yield of native coffee[2] has been steadily declining since 1868, owing to the want of high cultivation and manuring which have, in some measure, at least, saved the plantation coffee from being subject to the full influences of the disease. The culmination of crop and total value for native coffee was reached in 1868, the year before the leaf disease appeared, when 218,584 cwt. were exported. In 1877 the export of native coffee had fallen to 76,182 cwts., only a little over a third of what it was in 1868.[3] The influence of the disease has also seriously reduced the yield per acre. The Rev. R. Abbay, in the paper mentioned above, states that "Previous to and including 1871 the average yield for five years over the whole island had been 4·5 cwt. per acre, whilst for the five succeeding years the average has only been 2·9 cwt. a decrease in the production of somewhat more than one-third."[4]

The deficiency in value of crop has been variously estimated; "the average annual deficiency in the whole island has been estimated by some as at least 2,000,000*l.* Since the 'disease' made its appearance in 1869, the coffee enterprise has suffered to the extent of from 12,000,000*l.* to 15,000,000*l.* in crops alone."[5] A portion of the loss which the coffee estates have suffered may be and is, no doubt, due to exceptionally unfavourable seasons for the blossoming and development of fruit, and to the fact that many unsuitable areas were planted with coffee, which have since become unproductive; but there is a marked difference in the uniform succession of crops and in the yield per acre since 1871, even in the best coffee districts, which is evidently attributable to the action of the coffee-leaf disease.

When the trees are severely attacked by "disease," there is a premature fall of leaf and a check to the growth, which invariably results in a partial loss of crop. The trees also appear much thinner than formerly, having a wiry, sickly look, and do not make new wood so rapidly. As the disease shows itself mostly in dry weather, and just before the crop is ripening, its effect upon the trees is more severe and lasting than it otherwise would be; the tips of the branches often die back, involving, as the tree does not ripen all the berries, a great percentage of light coffee and black-hearted beans. The vitality of the trees being thus yearly weakened, there is often a failure of blossom even in what may be called favourable seasons, for though the blossom is forced out, it finds insufficient food-supply to support it, and, consequently, a large and wonderful show of blossom often ends in a total or partial failure of crop.

It appears that during the earlier years of its ravages the disease, after a very severe attack, would so completely disappear, and the trees, relieved from its enfeebling effects, would put forth such an abundant supply of new wood and foliage that it was confidently hoped that it was only a passing visitation, and that it would soon and entirely pass away. Even now its attacks are often confined for some time to certain districts, and even to certain parts of estates, but it seems to be seldom absent from patches of old and ill-cultivated coffee, and from native gardens. It soon, however, became evident, in spite of its fugitive character, that though the disease did not completely kill any trees, its accumulative effects upon them, and especially on the older trees, were such that they could not be depended upon to ripen their crop or to produce, except in alternating periods, a moderately average crop. In 1874 Dr. Thwaites reported that "there is great reason to believe, from what has been observed, that high cultivation, with judicious manuring, enables the tree to better sustain the attacks of the fungus, and to retain strength and vigour enough to produce a fair yield of berry." Encouraged by this opinion, planters adopted manuring operations generally, not as a cure for leaf disease, but in order to strengthen the trees and enable them the better to bear the double strain induced by crop and leaf disease. Though to some extent successful, it was noticed that, with the leaf disease present, the effects of manuring were not nearly so lasting as formerly, and were seldom apparent after the first or second year. There was also a less ready response on the part of the trees, and cases were not infrequent where trees had almost died out when forced to produce heavy crops, and others, where trees in a large degree had ceased to yield to any stimulus whatever.

3. *Remedial Measures.*—From what has been already mentioned it may naturally be supposed that the coffee-leaf disease and its effect on coffee cultivation in the East have occupied considerable attention during the last ten years, and, indeed, it may be looked upon as the most pressing and momentous of all questions affecting the prosperity and welfare of Ceylon, which depends so largely upon its coffee enterprise. Many suggestions have been made from time to time with regard to the application of suitable and effective remedies. As early as 1869 the Rev. M. J. Berkeley recommended the use of flowers of sulphur, or "one of the sulphurous solutions recommended for the extirpation of the hop-mildew," but the fugitive and deceptive nature of the disease and the vast area (over 200,000 acres) to be treated prevented any decided steps being then taken.

The hopes that were entertained respecting the temporary nature of the visitation and its possible mitigation by the application of suitable manures also led planters to look to indirect rather than direct means for checking the ravages of the disease. A few experiments were initiated, but from an imperfect knowledge of the disease and want of suitable apparatus no satisfactory results were obtained.

In January of this year a series of systematic experiments were initiated at Wallaha Estate, Lindula, in conjunction with the Hon. G. A. Talbot. In these experiments advantage was taken of the fact that the disease in its first or filamentous stage appears to exist as an *external* parasite upon the leaves and branches. It was found experimentally that an application of flowers of sulphur and coral lime entirely destroyed these external mycelial threads and without inflicting the slightest injury even to the most delicate parts of the plant.

This fact fully established, and being confirmed by subsequent experiments on larger areas, gave an entirely new aspect to the subject, and the present year has been signalised by an earnest and it is to be hoped a successful attempt to reduce the ravages of the coffee-leaf disease.

As sulphur had been used so extensively and so successfully against fungoid parasites in other parts of the world it may appear a matter of surprise that no steps had been taken long before this to test its efficacy on the coffee plant. In order to treat this disease successfully, however, it appears to be indispensable to carefully watch its various stages and apply specifics only when the disease is mostly external. During several months of the year, especially during a continuance of wet weather, the *vegetative* system of the *Hemileia* seems mostly to be developed, and as the mycelial threads are present *externally* upon the branches and leaves, it offers a favourable means for being treated.

Unfortunately the disease during this stage is entirely

[1] "Ferguson's Directory of Ceylon," 1876-78 Introd.
[2] Unpruned coffee grows with little or no cultivation in Sinhalese gardens.
[3] The falling off in native coffee is possibly not quite so much as these figures would indicate, for latterly an increasing quantity of native garden parchment is shipped as plantation coffee.
[4] Linnean Society's *Journal* "Botany," vol. xvii. pp. 173-5.
[5] *Ibid.*

microscopical, and it requires very close observation even with the microscope to detect it. It is no wonder, therefore, that planters found it most difficult to decide when and how to apply remedies, and these considerations, together with others incidental to coffee cultivation, rendered a successful treatment, without scientific aid, both difficult and laborious.

When the results of the first experiments at Wallaha were published, the importance of the subject led the Colonial Government to take up further investigations, and to render special scientific aid to the planters in conducting their experiments. Experiments were organised on a large scale, and carried on in various districts throughout the island.

Meetings were also held, in which the development of the disease, and the results of more extended experiments and observations were given in detail.

As a result of this combined activity, a series of reports has lately been presented to the Legislative Council of Ceylon, embodying the results of the "Leaf-disease Inquiry;" these are published in the Sessional papers of this year. The results of the investigations, so far, are briefly summed up as follows:—

1. That the coffee-leaf disease is an organised fungoid growth, present on the estates in some form or other all the year round.

2. That in December and the early part of the year it is generally present as an external parasite upon the coffee trees, in the form of long filamentous threads which cover every part of the bark and leaves.

3. That while an external parasite and in the filamentous stage it is possible to destroy it most effectually, and by so doing to save the trees from the attacks of the fungus for at least one year.

4. That a mixture of sulphur and lime dusted by hand into the tree in the proportions of one of sulphur to two of lime has been found by experiment to be the most effective and suitable remedy which can be applied.

5. That the cost of the materials, at present prices *in Colombo*, together with the cost of application, will not exceed at the rate of R 16-50 per acre.

6. That the application of sulphur and lime in the proportions recommended, by releasing the trees from a heavy drain upon their resources and restoring them to their natural condition, will be attended by a much more profitable result than any expenditure upon artificial manures.

7. That in order to assist the means used for checking the leaf disease it is most important that planters unite in the application of remedies and that they remove at once all sickly trees on their estates and those not likely to be crop producers, and prevent by every means in their power the re-infection of good coffee.

8. That in order to secure *perfect* freedom from leaf-disease it will no doubt be necessary to uproot all coffee trees on abandoned estates and old native gardens, and to take steps to prevent the disease from finding an asylum upon any plants not under careful cultivation.[1]

Judging by these results, which have been obtained by the united action of practical men of considerable knowledge and experience in coffee cultivation, aided by careful scientific observation, there is little doubt that the leaf disease can now be very effectually and conveniently treated, and if not completely exterminated, at least so materially reduced that it will not seriously injure the crops.

In the reports just quoted, great prominence is given to the necessity which exists for removing all old and sickly trees and up-rooting coffee plants growing without care or cultivation on abandoned estates and native gardens. Such trees appear to be the worst sufferers from leaf disease, and while they remain, are a continual source of danger to well-cultivated estates. One severely diseased tree is said to be sufficient to infect all trees in its immediate neighbourhood, and on that account a strong conviction is expressed in the Reports that little good can be expected from remedial measures of any kind, unless great care is taken to prevent the disease finding an asylum on "shuck" and abandoned coffee. The earnestness and intelligence which have characterised the action of the planters during the recent experiments lead to the hope that every means will be taken to check the development of the disease, and to increase the action of suitable remedies. The Reports also recommend the extended cultivation of other plants, such as tea and cinchona, in order to break the continuity of the coffee estates and restrict the action of the disease as much as possible.

On thus reviewing the present condition of coffee cultivation in Ceylon, there is much that is hopeful and satisfactory. Dr. Thwaites in his Report dated March, 1877, remarks that "Notwithstanding the continued prevalence of *Hemileia vastatrix* upon the coffee plants throughout the island, there would appear to be little, if any, diminution in the anxiety to invest in the cultivation of coffee; the high prices obtained, and the beneficial effects of judicious manuring, are giving so much confidence to planters." This feeling appears still to be maintained, for keen competition and high prices characterise all recent sales of suitable forest land. And while this shows that coffee cultivation still possesses the confidence of investors in new districts, many estates even in the oldest districts, are sold at prices which show they possess great vitality, and that where careful and intelligent cultivation is pursued they still offer a promising and attractive investment. It is gratifying to find that the planters are now quite conscious of the true nature of the disease, and thoroughly aroused to the necessity which exists for treating it on the lines which have proved so eminently successful for the last twenty years with the fungoid pests of the hop and vine.

By the extended cultivation of cinchona, tea, and other products, some of the conditions which have induced, or, at least, encouraged the ravages of the leaf-disease, will doubtless be removed, and in the renewed care and intelligence which are becoming daily more apparent in the methods of cultivation and the application of suitable manures, there is every reason to believe that coffee cultivation in Ceylon will be carried on under much more advantageous circumstances than at present, and while much that is now under coffee will probably be planted with tea and cinchona, the remaining lands will receive that due care and attention which cannot fail in time to restore the coffee estates of Ceylon to the position they have long held as one of the most successful and important of the enterprises of the East. D. MORRIS

Kew, September 3

[1] Morris's Reports on "Coffee-Leaf Disease," Sessional Papers, Legislative Council of Ceylon, 1879.

OUR ASTRONOMICAL COLUMN

THE SATELLITES OF MARS.—In the Introduction to his Tables of the satellites of Uranus, Prof. Newcomb points out the advantage that might be derived, in systematic observations of the satellites by the preparation of a table showing the angles of position and distances corresponding to every 10° in u or the longitude of the satellite in its orbit, counted from the point in which it crosses the plane parallel to the earth's equator. From such a table the approximate positions of the satellites would be obtainable at any one opposition, with no further calculation than is required to determine the value of u for the time of observation. The more rapid geocentric motion of the planet Mars does not of course allow of this principle of computation being applied so as to attain the same degree of approximation as in the case of Uranus, but even with Mars it is likely that such a table, prepared with the values of the various auxiliary quantities for the date of opposition November 12, may facilitate observations, and we accordingly present one below:—

Argument u.		Position.		Distance.	
A.	B.	A.	B.	*Deimos.*	*Phobos.*
0°	180°	178°·8	358°·8	20″·4	8″·2
10	190	144·5	324·5	16·8	6·7
20	200	109·3	289·3	19·9	8·0
30	210	88·4	268·4	27·3	10·9
40	220	77·0	257·0	35·8	14·3
50	230	70·1	250·1	44·2	17·7
60	240	65·3	245·3	51·6	20·7
70	250	61·4	241·4	57·7	23·1
80	260	58·4	238·4	62·3	25·0
90	270	55·6	235·6	65·2	26·1
100	280	53·1	233·1	66·2	26·5
110	290	50·5	230·5	65·1	26·2
120	300	47·8	227·8	62·6	25·1
130	310	44·8	224·8	58·0	23·3
140	320	41·1	221·1	52·1	20·9
150	330	36·4	216·4	44·8	17·9
160	340	29·6	209·6	36·5	14·6
170	350	18·7	198·7	27·9	10·6
180	360	358·8	178·8	20·4	8·2

According to Prof. Newcomb's elements the values of the argument u at Greenwich mean midnight are—

Nov. 2	*Deimos* 331°·1	*Phobos*	89°·8
12	,, 302·7	,,	217·7
22	,, 274·4	,,	345·7

and the diurnal motions of u are 285°·1645 and 1128°·794 for *Deimos* and *Phobos* respectively, giving hourly motions of 11°·882 and 47°·033, whence u for the time of observation may be found. Or if the observer possesses Newcomb's memoir on the satellites he may find it from the table at p. 42. Then with u as the argument the above table gives roughly the angle of position and distance of the satellite, remarking that the former is to be taken in column A or column B, according as the argument is found under A or B. Thus for midnight on November 5 the value of u for *Deimos* is 106°·6, and for *Phobos* 236°·3, whence the positions and distances are: for *Deimos* 51° and 65″, and for *Phobos* 247° and 20″.

THE SATURNIAN SATELLITE, MIMAS.—This faint object was observed by Mr. A. Ainslie Common, of Ealing, with his 3-feet reflector, on the night of September 21, when close up to its conjunction with the following extremity of the ring, which was estimated to take place about 11h. 50m. G.M.T. With the elements which have been previously used in this column the satellite would be up to the ring at 11h. 53m. Such observations as this are of course much more valuable for the correction of elements than estimations of the times of greatest elongations; nevertheless as it is in or near the latter positions that the satellite is most likely to be visible in telescopes of inferior power, we subjoin the times of greatest elongations observable in this country up to the end of the present month:—

East.	h. m.	West.	h. m.
Oct. 9 ...	12 20	Oct. 16 ...	13 56
10 ...	10 56	17 ...	12 33
11 ...	9 53	18 ...	11 10
12 ...	8 10	19 ...	9 47
13 ...	6 47	20 ...	8 23
		21 ...	7 0
24 ...	14 10	Nov. 2 ...	12 58
25 ...	12 47		
26 ...	11 24		
27 ...	10 0		
28 ...	8 37		
29 ...	7 14		

THE MINOR PLANETS.—Two small planets assumed to be new have been detected by Prof. Peters, of Clinton, N.Y., apparently on September 22 and 26 respectively; the number being thus raised to 203. Prof. Watson, now in direction of the Washburn Observatory, Madison, Wisconsin, has selected the following names for planets discovered by him in 1877: for 174, *Phædra;* for 175, *Andromache;* and for 179, *Clytemnestra. Fortuna* will be in opposition on October 23 close up to perihelion, so that the possible brightness, 8·5m., will be at its maximum.

GEOGRAPHICAL NOTES

DR. HOLUB, the eminent African traveller, who is now in England on his way to his native country (Bohemia), intends, it is stated, shortly to undertake another exploring expedition. His return to Europe has for its main object the collection of the necessary funds for the new undertaking. He has formed plans for the formation of an international expedition, which is to be placed under his direction and which is to travel through Africa from Port Elizabeth towards Egypt. The exploring party is to consist of twelve members representing twelve different nations, and the costs of the expedition are to be defrayed by the different governments. The special purpose of the expedition is stated to be the opening of Central Africa towards the south and east and to facilitate the colonisation of the district between the Vaal River and the Zambesi. A correspondent in the *Times* gives the following interesting summary of the remarkable work accomplished by Dr. Holub:—"For seven years Dr. Holub has been exploring the country north and south of the Zambesi, alternating his exploring expeditions with months spent at the Diamond-fields, practising as a medical man to raise the requisite funds for his next journey. In this time the doctor has studied the habits of the Matabele, the Marutsi, Hottentots, Bechuanas, and numerous other tribes, living among them as their guest, and gaining their confidence by curing their sick. In Dr. Holub's third and last journey he has accurately surveyed the country from the Diamond Fields to the Zambesi, and the Zambesi from its junction with the Chobe to the Barotse country. His map of the Zambesi is on a large scale, and shows every island, creek, and rapid. To show the difficulties of this survey, it may be mentioned that, owing to the loss of his *Nautical Almanac,* his sextant was useless, and the bearings had to be taken by compass observations every 300 yards, while the distances, amounting in the various surveys to over 2,000 miles, were determined by *stepping.* That is, the explorer counted every step he took during a twenty-one months' walk. He arrived at Muchela Amsinga tired and unwell, but still full of pluck, and hoping to cross the continent and emerge at Loanda. Then fever came on, and his best canoe, containing all his gunpowder, and, worse than all, his quinine, sank in a rapid. He still pushed on, but at the Nambwe cataract he succumbed, and was carried back insensible by his native servants to lie ill during a period of sixteen months. Even during his illness, however, he was not idle, for being carried about in a litter and directing his men what to pick up, he made magnificent collections of plants and insects, with others of birds, weapons, native drawings, &c. The collection of beetles alone contains no less than 13,000 specimens. Dr. Holub is publishing the account of his journeys in Bohemian, English, German, and French, and is about to read a paper before the Geographical Society of Vienna. He will also read one before the Royal Geographical Society of London when he returns to England at Christmas."

DR. OTTO FINSCH, of Bremen, who is on a tour to Micronesia, by order of the Humboldt Institution of Berlin, arrived at Honolulu on June 17, and first of all proceeded to the island of Maui, where he spent some time in making scientific collections and observations of the Haleakala, the largest volcanic crater on the globe. After his return from Maui he made an excursion to the Bay of Waimanolo in order to visit the ancient Hawaiian

burial-grounds. The traveller has collected some 3,000 zoological and 300 botanical specimens, besides a splendid series of Kanaki skulls; all these collections were packed ready for conveyance to Berlin when he sent the news. On July 27 he left Honolulu for Jaluit (Bonham) in the Marshall group, and has no doubt by this time reached the very district he is specially to investigate. From Jaluit he will proceed to other islands in the neighbourhood.

FROM an early sheet of *Petermann's Mittheilungen* we learn that the Dutch exploring vessel *Willem Barents* arrived at Hammerfest on September 24, having succeeded in reaching Franz Josef Land. The expedition encountered stormy weather in September, and found much ice in the Kara Sea and to the north of Novaya Zemlya. M'Clintock Island, in the south of Franz Josef Land, was surrounded by ice, and on the return journey ice was found east of the 55th degree. They left the *Isbjörn* in Matotschkin Scharr. This *Isbjörn* is the little Norwegian cutter in which Capt. Albert Markham and Sir Henry Gore Booth have been cruising in the Novaya Zemlya seas, and which reached Tromsö on September 22. On June 4 they met with the first ice forty miles from the west coast of Novaya Zemlya, and finding Matotschkin Scharr impassable, they sailed along the west coast of Novaya Zemlya to Cape Nassau, when the *Isbjörn* was stopped by ice. Returning again, the Matotschkin Scharr was passed, but the Kara Sea was full of masses of ice. On their return they fell in with the *Willem Barents*, and Markham decided to press northwards again, and this time succeeded in reaching, on September 6, Cape Mauritius, the north point of the island. Pressing still further northward between Novaya Zemlya and Spitzbergen, the *Isbjörn* reached 78° 24′ N. lat., only about eighty miles from Franz Josef Land.

ADVICES received from St. Lawrence Bay state that the American Polar exploring vessel *Jeannette* arrived there on August 25, and sailed for Cape Serdze Kamen after taking in coal. It is believed that there is a prospect of an open winter in the Arctic Sea this year.

IN his last official report from Copenhagen, Her Majesty's Consul states that the Danish war vessel *Fylla*, which during the fishing season is stationed off the coast of Iceland, has made some deep-sea soundings and measurements, and brought home many interesting particulars respecting the currents and temperature of the Polar Sea. On one of these expeditions she penetrated so far north in the ice as to find cold water (*i.e.*, under freezing point) from two fathoms below the surface to the bottom, by which was proved the presence of an ice-cold polar current; the existence of this had not been previously ascertained, owing to the impenetrable ice-masses. The soundings were taken both on the north coast and in Denmark Sound. The extent of the polar ice is varying and changeable, for at the time the *Fylla* was able to penetrate many miles direct north in open water from North Cape, Iceland, a mail steamer could not enter Ofjord owing to the ice, and a French war steamer was stopped by ice about five miles from the coast between these points. During the whole time the *Fylla* met with very much drift-wood, which increased in quantity as she advanced northwards. The foregoing notes are of considerable interest when considered in connection with portions of Mr. G. F. Rodwell's letter from Iceland, in last number.

THE October number of the Geographical Society's monthly periodical opens with a long paper by Capt. G. Martin, on the information obtained in regard to the Kurram Valley during the survey operations of the Afghan expedition. At the present juncture, this paper will, no doubt, be read with much interest, but, though the author states that "he has endeavoured to be as brief as possible," we incline to the opinion that his observations might with advantage have been very considerably curtailed. In the geographical notes we find news respecting the Rev. T. J. Comber's expedition to the Congo, Danish discovery on the coast of Greenland, and the Dutch Arctic expedition. Some further particulars in regard to Mr. Keith Johnston's sad death and the East African expedition are also included under this head.

THE Marine Survey Department, Calcutta, has lately issued a hydrographic notice which contains some information in regard to Pemba Island and the adjacent coast of East Africa. The island is thirty-eight miles long and about thirteen miles wide, including the islands on its western side, which protect the numerous harbours there. The east coast is rocky and straight, with only a few slight indentations. The height of Pemba Island does not exceed 300 feet, and the surface is broken into ridges and valleys, covered with luxuriant vegetation. The soil is rich, the chief produce being cloves, most of the groves of which are situated on the west side of the island. All tropical cereals and edible roots flourish, and on the eastern side the Wapembe, or descendants of the aborigines, keep large herds of cattle. Cocoa-nuts abounded, but no oil-making is carried on, most of the nuts being consumed locally and the remainder sent to Zanzibar to be converted into oil. The greater part of Pemba Island is under cultivation, or is grazing-land, but a little forest exists here and there. The island is governed by a Wali, appointed by the Sultan of Zanzibar, and residing at Chaki Chaki, the only place of any importance.

NOTES

WE learn that Dr. Thwaites, F.R.S., C.M.G., has resigned the directorship of the Royal Botanic Gardens, Peradeniya, Ceylon, to which he was appointed in 1849. This step has been for some time contemplated by Dr. Thwaites, on whose somewhat feeble health the charge of the botanical interests of the island, especially in relation to the coffee-leaf disease and the introduction of new kinds of cultivation, has of late pressed heavily.

IN a recent paper to *La Nature* on the employment of the hydro-electric batteries and Reynier lamps for domestic lighting, M. Reynier comes to the following conclusions :—The most powerful battery is the Bunsen, Ruhmkorff model; but it is inconvenient and deleterious, and expensive. The most economical and constant battery is the Thomson; but it is costly and cumbrous. The most convenient battery would be a well-arranged rotatory one; but the price would be high (200 fr. at least) and the daily cost enormous. A battery as powerful as the Bunsen, as economical as the Thomson, and as convenient as a well-arranged rotatory one, would still be far from suitable for electric lighting. Hence it is not at present among hydro-electric batteries that we have to look for the solution of a domestic motor applicable to the present electric lamps.

AS will be seen from our advertising columns, the Council of the Entomological Society of London is authorised by Lord Walsingham and other gentlemen interested in the diseases of our native game birds to offer to public competition the following prizes :—50*l.* for the best and most complete life-history of *Sclerostoma syngamus*, Dies., supposed to produce the so-called "gapes" in poultry, game, and other birds; 50*l.* for the best and most complete life-history of *Strongilus pergracilis*, Cob., supposed to cause the grouse disease. No life-history will be considered satisfactory unless the different stages of development are observed and recorded. The competition is open to naturalists of all nationalities, and the same observer may compete for both prizes. Essays in English, French, or German, to be sent in on or before October 15, 1882, addressed to the

Secretary of the Society, 11, Chandos Street, Cavendish Square, W.

THE death is announced of Prof. Mohr, of Bonn University, at the age of seventy-two. Mohr, like his father, was originally an apothecary at Coblenz. In 1864 he was attached to Bonn University, and some of his works on chemistry, geology, and physics have been translated into foreign languages. His activity was inexhaustible.

AN experiment was tried on October 4 by M. Menier, in a large park belonging to him at Noyelles, on the banks of the Marne, about 50 kilometres from Paris, on the Eastern Railway. A part of the water power which he uses for his workshop operates on eight ordinary Gramme machines producing the current for the Serrin regulators or Jablochkoff candles. The current of two of these machines was sent into the park at a distance of 700 metres, where two others had been arranged on a truck and connected with a plough by a dragging rope. A number of furrows were then traced with this simple apparatus, and have been found equal to the work of four oxen. The experiment has been found so successful that M. Menier intends devoting a water-power of thirty horses to agricultural work round his workshop. He intends using water-pipes for placing his insulated copper wires, and expects to conduct his power to 5 kilometres from his mill in every direction, so to perform various agricultural operations on a surface of more than ten square miles.

THREE different telephonic companies are competing in Paris, viz., the Gower (magnetical), Bell, and Edison, the two latter working with the microphone. It is said that the Bell and Edison Companies will enter into a working arrangement, or a fusion.

THE city of Lille, in French Flanders, sends every year to England the best English scholars of the Municipal School. This year the journey made at the expense of the city has taken unprecedented extension. The number of travelling pupils was twenty-three, and the excursion occupied a fortnight, during which not only London, but Edinburgh, Dundee, Glasgow, Newcastle, Durham, and York were visited.

THE tramway from Naples Observatory to the foot of the cone of Mount Vesuvius is nearly completed, and will be opened early next year. A steam-engine at the summit will draw the trams up by a windlass on Spielg's system.

WE understand that by the retirement of Dr. Gilchrist from the charge of the Crichton Asylum at Dumfries, a very important and valuable appointment is now open to the psychological branch of the medical profession.

A FACULTY of Medicine has been created at Bordeaux. M. Ferry, the Minister of Public Instruction, will be present at the ceremony of laying the first stone.

THE French Minister of War has published a regulation for organising optical telegraphy in time of peace. The several places on the French frontier are to be connected by posts; apparatus are to be manœuvred by persons trained and keeping records of communications sent or received. This new service is to be placed under the supervision of the Director of Aërial Communications, who already has command of the balloonists and the colombophiles for carrier-pigeons.

THE *Times* Geneva correspondent states that a fisherman has found a very remarkable weapon near the lake-dwelling of Locras, in the Lake of Brienz. It is a double battle-axe of pure copper, forty-two centimetres long, and weighing three kilogrammes. Massive and heavy in the middle, it broadens out gradually into two cutting edges, each having a width of twelve centimetres. It has been added to the collection of Dr. Gross, at Neuveville. Several similar weapons have been found in Denmark; but, so far as is known, this is the first of the kind discovered in Switzerland. The lake-dwelling of Locras is assigned by archæologists to the age of stone.

AT Trier (Treves) a fresh discovery of colossal remains of Roman structures has recently been made. They consist mainly of a large wall, 1·88 metres thick, with two other ones running parallel to it and only 90 centimetres apart. Between the latter two, at a depth of 8 metres below the present surface of the ground, there is a vaulted canal, and a little further on an enormous cellar vault. The foundations of the two parallel walls have in some parts not been reached at a depth of 9 metres. Archæologists are at present at a loss to know what may originally have been the nature of the structure, as nothing at all resembling it has ever been discovered.

WE have received from the Dundee Naturalists' Society very satisfactory reports of the work done during the sessions 1877-8-9.

IN a recent communication to the Vienna Academy, on the cause of excitation of electricity in contact of heterogenous metals, Prof. Exner offers proof that the electromotive force is always in direct relation to the heat of combustion of the metals in question, provided they are in air. Such proof is quantitatively furnished for the combinations of Zn, Cu, Fe, and Ag, with Pt. Further it is shown that the so-called contact-force of two metals changes, whenever these are no longer in air, but in some gas acting in a different way on them chemically. Numerical proof of this is given in the case of Ag, according as this metal is in air or in an atmosphere of chlorine. Since the numerical values obtained in this research, for the contact-force, as also the few older determinations are in full harmony with the chemical theory of this mode of electric excitation, and the experiments are contrary to the voltaic theory, the author considers further adherence to the latter impossible.

THE radicles of seeds lying on the surface of the ground penetrate into the ground only under certain conditions. According to recent observations by Dr. Richter, of Vienna, these are of the following nature:—1. The penetration takes place only when the temperature exceeds a certain minimum above the lower zero of germination, depending on the species of the plant. 2. This minimum is much lower, for one and the same plant species, if the seedling is exposed to light, than if it is kept in darkness, the reason being that in the former case a transformation of light into heat occurs (as shown by experiments of cultivation at temperatures above the optimum of germinating temperature of particular plants). 3. A pressure of the roots on the ground, whether through formation of root-hairs, or from external causes, favours the penetration of the roots. 4. The nature of the ground affects the penetration of roots, only in that the latter occurs more easily the less resistance the ground presents to the roots. 5. Geotropism is naturally concerned most largely in the penetration of the roots. The light affects it in so far as by production of heat, it favours the growth generally, and therewith the geotropic downward-bending. On the other hand, negative heliotropism is (contrary to expectation) not concerned in penetration of illuminted roots into the ground.

THE Rouen journals report an invasion of swarms of bees in several houses of the town. In a confectioner's establishment legions of these bees took possession, making it impossible for the workmen to continue their occupations. Nearly every inmate of the place was stung, and one person was maltreated so severely that medical aid had to be called in. An attempt was made to get rid of these importunate guests by burning sulphur to asphyxiate them, but the bees took refuge in the upper storeys

and when the smoke had abated, they descended again, and were as troublesome as before.

THE general meeting of German Archæologists and Historians took place at Landshut (Bavaria) on September 14 last, and was well attended by members from all parts of Germany. Prof. Ohlenschlager, of Munich, delivered the first lecture "On the Survey made of the so-called Devil's Wall in Bavaria." Great interest was evinced in a paper read by Prof. Rhiza, of Vienna, "On the Marks made by Masons and Stone Workers at different Periods and in Different Districts."

KARL VON SCHERZER, Austrian Consul-General at Leipzig, has been nominated honorary member of the Senkenberg Natural History Society at Frankfort-on-the-Main.

THE "Oberlausitzische" Scientific Society at Görlitz (Silesia) celebrated the centenary of its foundation on October 8. At the same time the 153rd General Meeting of the Society took place.

AT the Baden-Baden meeting of the International Society for the Prevention of the Pollution of Rivers, the Soil, and the Atmosphere, which took place on September 16 last, the three principal addresses were by Professors Reclam, of Leipzig, Vogt, of Berne, and Ewich, of Cologne. Prof. Reclam spoke on canalisation and the pollution of rivers in Germany and England; Dr. Vogt on the influence of the sun upon the walls of houses; and Dr. Ewich on the origin of springs and wells.

IT may interest our readers to know the elevations which at present are reached by lines of railway in different parts of the world. The Apennine Railway reaches its highest point at an elevation of 617 metres above sea-level; the Black Forest Railway ascends to 850 metres, the Semmering line to 890, the Caucasus line to 975 metres. The St. Gothard tunnel is 1,154 metres above sea-level; the railway across the Brenner reaches 1,367 metres; the Mont Cenis Railway ascends to 1,338 metres, the North-Pacific line to 1,652, the Central-Pacific to 2,140, and the Union-Pacific to 2,513 metres. The highest of all is the line across the Andes, which reaches an elevation of 4,769 metres.

DR. BRAUNS, of Halle, has been appointed Professor of Mineralogy and Palæontology at the Japanese University of Tokio. It is stated that some twenty-five amongst the teachers at this University are Germans.

AT Carlsruhe a meeting of a large number of agricultural chemists from all parts of Europe took place on September 16 and 17 last.

WE have a satisfactory report of the Queenwood Mutual Improvement Society for the end of the summer term 1879. A good deal of practical natural history work seems to be done by the members, and the report contains an interesting account of three carrion crows that were tamed by some of the boys, remaining about the premises, "showing themselves as familiar and companionable as the most faithful dogs."

ON Thursday last the Chester Society of Natural Science held a very successful *conversazione*. The Kingsley Memorial Medal, established in memory of the Society's first president, was awarded to Sir P. de M. Grey Egerton, for "having contributed materially to the promotion and advancement of natural science," and the Kingsley Memorial Prize to Mr. G. Shrubsole, jun., for his collection of fossils illustrating the carboniferous limestone, millstone grit, and coal measures.

MR. F. H. BROOK, of Walworth, has sent us a useful Price List of Electrical Apparatus, containing upwards of 450 items.

THE annual exhibition of the Photographic Society was opened on Monday, at the Gallery, 5, Pall Mall, East.

WE very much regret to learn that the publishers of the *American Chemist* have been obliged to discontinue the publication of that valuable journal.

A DISCOVERY calculated to throw some light on prehistoric man has recently been made by the excavation on the banks of Lake Ladoga of a human skeleton belonging to the stone period, along with many well-preserved skulls and bones, remains of plants and animals, and instruments of stone and bone. These remains were found at a depth of from about 12 to 20 feet below the surface of the lake.

TWO shocks of an earthquake were felt at Annecy, Savoy, at 4 A.M. on Saturday, both accompanied by a rumbling noise.

MR. STANFORD has published a useful Section of British Strata, showing the order of superposition and maximum thickness of strata in the British Islands, by Mr. James B. Jordan. The section was originally prepared as an Index of Colours to Stanford's Geological Map of the British Islands, edited by Prof. A. C. Ramsay, by whom it has been revised and corrected.

THE Museum of the French Colonies at Paris, which, as we stated, has received a sensible augmentation by the addition of a large part of the Algerian collections, is undergoing a total reorganisation. A new director and sub-director have been appointed.

THE Peking correspondent of the *North China Herald* learn that the engagement of the geologist and mining expert, Mr. Arnold Hague, by Li Hungchang, has terminated, owing to the obstructions constantly put forward by the Central Government. A few metal-bearing localities have been examined, but noting definite has been learned of the resources of the province of Chihli. At the date of the letter referred to Mr. Hague was at Peking, on his way to Mongolia, where he intends to make some excursions, partly with a view to scientific investigations. He will afterwards return to the United States to take up an official appointment in connection with certain new systematic surveys which it has been determined to make there.

THE Government of Victoria have just appointed a board to advise them as to the best mode in which assistance can be given to further the development of the auriferous and mineral resources of the colony.

NO. 3 of "Dimmock's Special Bibliography" (Cambridge, U.S.) consists of a full list of the writings of Samuel Hubbard Scudder, which ought to be specially valuable to entomologists.

WE have on our table the following works:—"The Spiders of Dorset," Rev. O. Pickard Cambridge; "Chemical and Geological Essays," by T. Sterry Hunt (Trübner); "Deaths in Childbed," Dr. Æneas Munro (Smith, Elder, and Co.); "The Silk Goods of America," W. C. Wyckoff; "Structural Botany," Dr. Asa Gray (Trübner); "Luxurious Bathing," A. W. Tuer (Field and Tuer); "Phrenology Vindicated," A. L. Vago (Simpkins); "On the Diffusion of Liquids," J. H. Long (H. Laupp); "Reform Essays on Incentive Religion and Warfare;" "Farming for Pleasure and Profit" (Poultry Keeping), Arthur Roland (Chapman and Hall); "Manual of Practical Anatomy," J. Cossar-Ewart (Smith, Elder, and Co.); "Rays from the Realms of Nature," Rev. James Neill (Cassell); "Jack's Education; or, How He Learnt Farming," Prof. Henry Tanner (Chapman and Hall); "Vocal Physiology and Hygiene," Gordon Holmes (Churchill); "Fauna der Gaskohle und der Kalksteine der Perm Formation Böhmens," Dr. Ant. Fritsch.

THE additions to the Zoological Society's Gardens during the past week include a Vervet Monkey (*Cercopithecus lalandii*) from South Africa, presented by Sir Arthur Scott, Bart.; a White-

cheeked Capuchin (*Cebus lunatus*) from South America, presented by Mr. Adrian Hope, F.Z.S.; an American Red Fox (*Canis fulvus*), a Rough-legged Buzzard (*Archibuteo lagopus*) from Labrador, presented by Lord Hobart; three Vulturine Guinea Fowls (*Numida vulturina*), a Crested Guinea Fowl (*Numida cristata*) from East Africa, presented by Vice-Admiral John Corbett, C.B.; two Malabar Mynahs (*Sturnia malabarica*) from Hindostan, a Chinese Mynah (*Acridotheres cristatellus*) from China, a Waxwing (*Ampelis garrulus*), European, presented by Mr. A. F. Weiner, F.Z.S.; five Fat Dormice (*Myoxus glis*), European, presented by Mr. Edwin Liot; seven Green Tree Frogs (*Hyla arborea*), a Green Lizard (*Lacerta viridis*), three Spotted Salamanders (*Salamandra maculosa*), European, presented by the Rev. S. R. Wilkinson, F.Z.S.; an Anaconda (*Eunectes murinus*) from South America, presented by Capt. E. Ball; an Elliot's Guinea Fowl (*Numida ellioti*), a Vulturine Guinea Fowl (*Numida vulturina*), three Mitred Guinea Fowl (*Numida mitrata*) from East Africa, a Booted Eagle (*Nisaetus pennatus*), European, purchased.

ON THE GRADUAL CONVERSION OF THE BAND SPECTRUM OF NITROGEN INTO A LINE SPECTRUM

PROF. WÜLLNER, of Aachen, has recently published a treatise on the two different views which are held by physicists with regard to the various spectra presented by gases which are rendered incandescent by means of induction sparks. One of these views was first stated by Ångström, who thought that for a certain gas only one spectrum was possible, and that this spectrum consisted of lines only. All band spectra which occasionally appeared when gases were examined in the way mentioned, he ascribed to impurities. The band-spectrum of nitrogen, according to his idea, belonged to oxides of that element. He believed that as long as the current passed through the gas without giving a spark, the oxide was rendered incandescent as such, without decomposition, and that the spark decomposed the oxide, and that only then the nitrogen could give its own line-spectrum. Later on Ångström modified this view, and admitted that an elementary substance might give several spectra when rendered incandescent in the gaseous state, but he still held that in this case the element in question entered into isomeric compounds with itself, and that the different spectra belonged to different isomeric compounds. Mr. Lockyer afterwards defined this view more clearly, stating his opinion that the line-spectrum is produced by simple atoms, and the continuous or channelled-space spectra by conglomerations of molecules.

Prof. Wüllner, however, does not consider this hypothesis necessary for the explanation of the different spectra of elements, but holds that they may be explained by Kirchhoff's maxim. Prof. Zöllner has pointed out that the light emitted by a radiating layer of gas must essentially depend on the thickness and density of the layer. Prof. Wüllner, therefore, after having first confirmed the fact that the line-spectrum of elementary gases only appears with the real electric spark, the band-spectrum, however, when in the gas the electro-positive brush and glow appears, ascribes the different spectra to the differences in the radiating layers of gas. He believes that in the spark only the molecules struck by the spark are glowing, therefore almost only a linear row of molecules; thus in the spectrum only the absolute maxima of the emission power, which correspond to the temperature of the spark, become apparent. If, however, in the positive brush light the whole quantity of gas contained in the spectral tube is rendered incandescent, then it is always a relatively thick layer which emits light; in the spectrum all those kinds of light must show themselves for which at the respective temperature the power of emission is above zero. But since the incandescent gas is always of relatively small density, all the differences in the emission power of the various kinds of light must become apparent in the spectrum, and thus the latter must be richly varied or shaded; this is indeed the case in the band-spectra of gases. Prof. Wüllner adduces the spectra of iodine vapour as proofs of the correctness of his view. When rendered incandescent by means of a hydrogen flame, iodine vapour gives the negative absorption spectrum, which is of the same character as the band-spectra of gases; if rendered incandescent through the spark, the glowing iodine molecules give a bright line-spectrum.

The band-spectrum of nitrogen shows, that this element at the temperatures obtained by electric discharges possesses quite as great a power of absorption as that of iodine vapour at low temperatures, because the band-spectrum of nitrogen is essentially of the same character as that of iodine vapour, however different it may be from it in detail. Of all other gases, nitrogen must therefore be particularly adapted for showing, through the examination of the light it emits, the dependence of spectral phenomena from the thickness and density of the radiating layer of gas, and thus for furnishing the proof that there is no constant spectrum of nitrogen, but that a certain spectrum exists only at a certain temperature and density of the gas. This indeed is the question upon which turns the difference of opinions of Ångström and Lockyer on the one hand and of Wüllner and Zöllner on the other; the former ascribing the different spectra to chemical differences in the molecular conditions of the gas, the latter merely to differences of temperature, density, and thickness of the radiating layer.

In a former treatise on the nitrogen spectrum, Prof. Wüllner, without having recognised the importance of the density of the radiating layer with regard to the light emitted, pointed out that when the pressure in a nitrogen tube is diminished to such an extent that it ceases to be measurable, the brightness of the spectrum decreases, and in such a manner that the darker parts first fade away, so that at last only the brightest parts remain. He added that in this way the nitrogen spectrum in its character approaches a spectrum of the second order (the name given to line spectra by Plücker) without, however, changing to the nitrogen spectrum of the second order, since no new bright lines appear. At that time, however, Prof. Wüllner did not continue his researches in that direction, and in particular he did not examine whether the bright parts remaining do indeed correspond to the maxima of the complete band spectrum, because the spectra he obtained at those pressures were too weak to allow of measurements being made with the instruments then at his disposal. Lately, however, the Professor has minutely examined the nitrogen spectrum in this sense, employing a simple contrivance for rendering the spectra bright enough for measurements, even at the lowest pressures. This consisted in the employment of spectral tubes of very narrow calibre (about 2 mm. in diameter).

It must be remembered here that the temperature of the gas, which is caused by the induction current, rises with decreasing diameter of the tube. (If, however, the tubes were taken too narrow, the current at once broke them.)

Since the resistance in the tube rises as the density of the gas decreases, at least from a certain point of low pressure downwards, the temperature rises as well. If the rise in the temperature was sufficiently great, the experiment described by Prof. Wüllner necessarily decided the only hypothetical part in his conception of spectral phenomena, viz., whether with a rising temperature the absorption power for the various kinds of light grows in a similar manner or not. If it does grow simultaneously with the temperature, then the relative maxima of intensity of light which the complete band spectrum shows must always remain the same; the bright parts remaining at the lowest density must correspond to the maxima of the band-spectrum. If the contrary is the case, and this is what Prof. Wüllner assumes, then dark parts in the band-spectrum may become the brighter ones as the density decreases, and the bright parts remaining at the lowest pressure may be situated at places in the spectrum differing widely from the maxima of the band-spectrum. The first part of the experiment therefore consisted in an exact determination of the relative maxima in the band-spectrum of nitrogen for the sake of comparison. This is minutely described in Prof. Wüllner's paper. The final results of the observations were in complete accordance with the Professor's conception of the spectral phenomena. There is indeed no definite nitrogen spectrum when in layers of sufficient thinness the density of the gas is reduced below a certain limit. The band spectrum changes step by step into a line-spectrum; this, however, is not identical with the line-spectrum produced by the spark, but has only a certain number of lines in common with it. In this gradual change it is easy to follow the displacement of the maxima of brightness which takes place little by little as the temperature rises, and is quite conspicuous in several places; this displacement is the very cause why in this line-spectrum the lines in places differ widely in their situation from the maxima of brightness of the band spectrum.

Prof. Wüllner then gives an exact description of that part of

the complete band-spectrum (at a pressure of about 5–10 mm.) in which the variability of the spectrum is most conspicuous, viz., in the green and blue (from wave-lengths 562 to 449); this is followed by an account of the gradual changes taking place in two different places when the density of the gas is decreased. It would lead us too far to enter into the details here; suffice it to say that the richly-shaded band-spectrum changes quite gradually into a line-spectrum, and that most of the lines of the latter are in places which show no maximum of brightness in the band-spectrum. It results from these observations that the positions of the maxima of emission-power do not remain at all the same in all temperatures, but that in consequence of the changes of temperature accompanying the decrease of pressure they may be considerably displaced.

Prof. Wüllner gives the reasons why the wider tubes are unsuitable for the gradual conversion of band-spectrum into line-spectrum, and eventually describes the differences between the line-spectrum obtained from the band-spectrum in the manner described, and the line-spectrum obtained by the spark. Upon comparison of those regions in the two spectra which were examined more closely (beginning at wave-length 572), it was found that in the spark-spectrum there are about forty lines in this region. Of these eight correspond very closely to maxima or lines in the fully developed band-spectrum. The number of coincidences with the lines of the low density line spectrum is, however, much greater; perfect, or very nearly perfect coincidence occurs in nineteen lines, *i.e.*, about half the number, and amongst these there are four which are the same in the three different forms of the nitrogen spectrum. The brightest lines of both line-spectra are, indeed, perfectly coincident. These are the yellowish-green lines 568,4 and 567,1, the green lines 500·7 and 500·4 (which result from the green-channelling described in detail) and the blue line 463·2 (developed from the blue channelling). Another interesting similarity exists between the two line-spectra, however differently about half of their lines may be situated.

Plücker and Hittorf distinguish five principal groups in the line-spectrum of nitrogen, between which there are other single lines. Of these five groups Nos. II. to V. belong to the region specially studied by Prof. Wüllner. These groups are:—

Group II. between wave-lengths 577—567
Group III. " " 555—545

Between groups III. and IV. there are first three lines: 535·6, 534·4, and 532·3; and then two lines: 518·1, and 517·6.

Group IV. between wave-lengths 508—499

Between groups IV. and V. there are first four lines: from 489·6, to 484·8, and further on three lines: 480·5, 479·0, and 478·1.

Group V. between wave-lengths 464·5—460·2.

All these groups are situated in such parts of the spectrum where also the line-spectrum developed from the band-spectrum is very rich in lines. It follows, therefore, that the spark-line spectrum is developed, on the whole, in such places which show the greatest variability, even in a gradual decrease of the density of the gas, and which are richest in lines in the low-density line-spectrum.

Prof. Wüllner recapitulates his interesting treatise in the following manner:—The course of spectral phenomena of nitrogen, which takes place when the gas is gradually reduced in density in tubes of sufficiently small diameter, shows exactly those changes which may be deduced from Kirchhoff's maxim, that the smaller the number of incandescent molecules, the more the spectrum contracts into a number of bright lines.

At the same time it may be directly observed when the density of the gas is decreasing, how, in consequence of the temperature rising through increasing resistance in the tube, the maxima of brightness change their position, how the maxima of the fully-developed band-spectrum fade away, and how the lines become prominent in places which are either secondary or tertiary maxima or uniformly illuminated regions in channelled spaces. Now, if we further consider that the lines of the spark-spectrum, compared to those of the former line-spectrum, are not more considerably displaced than the latter are with regard to the maxima of the band-spectrum, then we can hardly doubt that in the different forms of the nitrogen-spectrum we see nothing else but the light emitted each time in accordance with the different temperature, density, and thickness of the radiating layer of gas, and that a new hypothesis for the explanation of these spectral phenomena is unnecessary and superfluous.

A HISTORICAL SKETCH OF THE VARIOUS VAPOUR-DENSITY METHODS[1]

ALTHOUGH Southern,[2] in 1803, made some very careful experiments to determine how much water was required to furnish 1 cubic foot of steam at various pressures, still the foundation of vapour-density methods was laid by Gay-Lussac.

He, in 1811,[3] started on the correct basis of accurate work when he heated a weighed quantity of substance over mercury in a graduated vessel. Muncke, in 1816,[4] heated the substances *in vacuo* in elliptic glass balloons of 155 c. i. capacity, closed with a stop-cock and with thermometer and syphon barometer suspended inside. In 1822[5] Cagniard de la Tour determined the combined effects of heat and pressure on certain volatile liquids, but as his results were on the question of maximum vapour-density, they hardly enter the domain of the present sketch. In the same year Despretz,[6] who gave no drawing, and only a very imperfect description of his apparatus, published a method in which he used a 9-litre exhausted globe, and made his determinations at atmospheric temperatures, employing only a small quantity of substance.

In 1826 Dumas,[7] wishing to operate on substances which attack mercury, worked out and published his well-known method in which the volume is definite, but the amount of substance required to fill that volume with vapour has to be subsequently determined.

In 1833[8] Mitscherlich proposed using tubes, sealed at one end and drawn to a neck at the other, instead of bulbs, and gave details and drawings of the apparatus for heating them; but Dumas, two years later, objected to the proposed alteration in his method, for he wrote:—

"We must then leave to this operation all its simplicity to make it essentially practical, and such, in fact, that with an ordinary cast-iron pot and some pieces of iron wire we can perform it. This is what I have done from the first, and what I persist in doing, my aim never having been to make a piece of apparatus for the cupboard of the physicist, but to give chemists a simple and eminently practical and yet exact process. After all *they* are the only ones to be considered."[9]

Deville and Troost,[10] however, in 1860, in referring to that same apparatus, called it "La méthode si élégante de M. Mitscherlich."

Bineau, in 1838,[11] published an elaborate paper, but unfortunately without any drawings, for when we read the following paragraph, "The bodies on which I have worked have been volatilised sometimes by the aid of heat by following the process of Dumas or that of Gay-Lussac, sometimes without elevation of temperature by working in the barometric vacuum or by allowing the vaporisation to take place in dry air or hydrogen," we cannot but feel that an enormous amount of valuable work has been lost for want of details. In 1844 we find Cahours,[12] as well as Bineau,[13] at work at the same subject. In 1846 the latter[14] repeated the experiments of Despretz with slight modifications, but called attention to the fact that the result was seriously affected by very small errors in reading off the mercurial column.

In 1849 Regnault[15] described an apparatus very similar to that of Mitscherlich, but arranged the tube supports so that the two could be withdrawn simultaneously; he also dispensed with sealing the tube containing air by providing it with a stop-cock. Bineau,[16] in 1859, in order to operate at high temperatures, coated the glass tubes with clay and heated them in a sand-bath.

Regnault,[17] in 1861, to obtain the same result, used iron tubes, and to ensure uniformity of temperature, heated them in a cast-iron tube which was made to revolve over gas-burners. The tube which served as air-thermometer was furnished with a stop-cock, but that containing the substance only terminated in a small aperture, and was not closed, as a sufficient quantity was

[1] Paper read at the British Association by Jas. T. Brown, F.C.S.
[2] *Phil. Mag.*, 30, 113 (1847).
[3] *Ann. de Chim.*, 80, 218 (1811); *Gilbert Annal.*, 45, 332 (1813).
[4] *Schweigger's Journ. Chem. Phys.*, 22, 1 (1818).
[5] *Ann. Chim. Phys.*, 21, 127 and 178 (1822); 22, 410 (1823).
[6] *Ibid.*, 21, 143 (1822); *Quart. Journ. Sci.*, 15, 297 (1823).
[7] *Ann. Chim. Phys.*, 33, 337.
[8] *Ibid.*, 55, 5–41 (1833).
[9] "Traité de Chimie," 5, 44.
[10] *Ann. Chim. Phys.* [3], 58, 259.
[11] *Ibid.*, 68, 416.
[12] *Compt. Rend.*, 19, 771 (1844); *Pogg. Annal.*, 63, 593 (1844).
[13] *Compt. Rend.*, 19, 768 (1844); *Liebig's Ann.*, 65, 424 (1845).
[14] *Compt. Rend.*, 23, 414 (1846); *Ann. Chim. Phys.*, 18, 226 (1846); *Ann. Chem. Pharm.*, 60, 158 (1846).
[15] "Cours de Chimie," 4, 66 (1849).
[16] *Compt. Rend.*, 49, 799 (1859).
[17] *Ann. Chim. Phys.* [3], 63, 54 (1861).

introduced before the heating, to allow it to be taken for granted that during the experiment there was no residual air.[1] Another method of Regnault's was to have two iron bottles of as nearly as possible the same size cast in one piece. In one of these the substance was placed, and in the other a small quantity of mercury. The necks were then partially closed by loose stoppers, and the system was heated in a muffle. After heating it was withdrawn and allowed to cool, and the quantities remaining in the bottles were determined by suitable means.

Grabowski,[2] in 1866, did much to shorten the Dumas calculation, while he allowed the method to retain all its accuracy and simplicity when he proposed to heat a bulb containing air in the same bath and of the same size as that containing the substance. After being heated the two bulbs were then sealed at the same temperature. Bunsen,[3] in 1867, employed an air-bath similar in principle to those of Mitscherlich and Regnault, but heated it by a very elaborate arrangement of gas-burners. He also simplified the calculation by taking care that *all* the tubes were of *exactly* the same weight and same size. He did not seal the tubes, but closed them by glass caps lined with india-rubber and fitted with glass plugs. Dumas,[4] in cases where the vapour rendered the outlet difficult to seal, used globes fitted with ground stoppers.

For the Dumas process at high temperatures Deville and Troost,[5] in 1857-9, recommended heating the bulb in a specially constructed furnace in the vapours of substances having high but definite boiling-points, such as mercury, sulphur, zinc, or cadmium (in 1873 Dewar and Dittmar[6] used a bath of boiling zinc in experiments on the vapour-density of potassium); for temperatures above the boiling-point of sulphur they used porcelain globes. For[7] temperatures up to that point the smaller and more compact apparatus devised by Greville Williams answers admirably.

Roscoe,[8] last year, in determining the vapour densities of the chloride of lead and thallium, used porcelain globes of 300 c.c. capacity, heated in a muffle, but determined the temperature by the method of specific heat, a large piece of platinum being employed for the purpose, and checked the result by the simultaneous determination of the vapour-density of mercury.

For[9] working at a reduced pressure Regnault proposed partially exhausting the bulb by means of an air-pump during the experiment; when the desired temperature was reached, it was sealed off at a point where the neck had been narrowed to a convenient size. In 1876 Habermann[10] gave a complete diagram of the apparatus, replacing the air-pump by a Bunsen-pump; but although he made no alteration in the method, still it was referred to by Sommaruga[11] as Habermann's.

The readiest method of determining the *residual* air is that of Greville Williams,[12] viz., to measure by means of a burette the quantity of mercury which is required to displace it. Deville and Troost[13] recommended weighing the mercury required.

Various experiments had been performed on vapours mixed with air, but the main point in Playfair and Wanklyn's[14] method (1861) consisted in stopping the supply of vapour before the bath in which the bulb was being heated had attained its maximum temperature.

Natanson,[15] in 1855, in order to use the Gay-Lussac method up to a temperature of 300°, heated the upper part of the tube by means of charcoal in a cylindrical furnace, and determined the temperature by thermometers suspended in the air-space between the graduated tube and the inner tube of the heating apparatus. In correcting for the tension of mercury-vapour he used Avogadro's tables.

Greville Williams[16] in 1857, wishing to make some determinations at varying pressures, devised the following method:—The graduated tube is, after it has been filled and the bulb has been inserted, screwed by means of a nipple cemented to the bottom into an orifice in the top of a small metallic cistern into a second orifice in which a long open glass tube is fitted. Into this tube mercury is poured until the required pressure is obtained. To reduce the pressure the excess of mercury is allowed to escape by a tap in the side of the cistern. The whole is heated in a water- or oil-bath.

In Regnault's[1] apparatus for the same purpose the two tubes are fastened to the bottom of the water-bath, and are connected by a T-piece, which is closed by a 3-way cock of special construction.

For determinations[2] up to 150° Greville Williams's compact modification consists in replacing the large vessel of mercury and the open glass cylinder by a cylinder closed and rounded at the lower extremity so as to resemble a large test-tube. This is then filled to a depth of 50–60 mm. with mercury, and above that with water or oil to a convenient height. The graduated tube is filled and the bulb inserted over the mercurial trough; it is then immersed in the large tube by means of a rod having at the end a small cup containing mercury. The large tube may be supported on wire gauze and heated by a Bunsen burner, or may be placed in a shallow oil-bath.

Schiffin,[3] in 1862, proposed steadying and manipulating the graduated tube by means of a loaded handle, which was secured to its upper extremity by spring clips.

Grabowski,[4] in 1866, replaced the charcoal furnace of Natanson by a very much neater air-bath heated by gas, but the chief merit in his method is that a tube containing air is heated by the side of that containing the substance. As soon as the substance is all converted into vapour, air is passed up into the second tube until it occupies as nearly as possible the same volume as the vapour. After the operation the air is measured at atmospheric pressure and temperature.

Croullebois,[5] in 1874, reverted to Bineau's method of using a large globe with a long tube, but took the precaution to heat the upper portion in a water-bath. Deville,[6] however, criticised his method rather severely, and pointed out that it was an unwieldy apparatus to manipulate.

In 1868, Hofmann,[7] in modifying the Gay-Lussac method, while he adopted the long tube which had been previously used by Bineau, Playfair, and Wanklyn, and Grabowski, introduced such an important alteration into the apparatus that it is not spoken of as his modification, but as his method. Instead of heating the substance-tube by a water-, oil-, or air-bath, he simply inclosed it in a slightly larger mantle tube, and passed the vapour of a liquid of definite boiling-point through the intervening space, selecting the liquid according to the temperature required. By this means he not only rendered the apparatus much more compact, but he maintained a steady temperature with the greatest ease. Wichelhaus,[8] in 1870, anxious to avoid the uncertainty introduced by the doubt as to the temperature of the column of mercury between the bottom of the outer tube, and the trough, dispensed with the latter by fixing to the lower extremity of the substance-tube an inverted syphon containing mercury. Then by lengthening and suitably enlarging the lower extremity of the outer tube, the whole of the inner one can be surrounded by vapour.

Grabowski,[9] in 1875, in order to obtain a high temperature, employed the vapour of naphthalene as the heating medium in using Hofmann's apparatus; but Engler,[10] in the following year, finding that the stoppage of the tubes from the solidification of the condensed hydrocarbon was troublesome, proposed to obviate the difficulty in the following manner:—He fixed to the lower end of the outer tube a metal socket provided with a short side-tube similar to those used for heating funnels. Then, by boiling the heating medium in this tube and allowing the vapour to cohobate in the space between the two glass tubes, he dispensed with all the arrangement of flask, tubes, and condenser.

Hofmann,[11] at the same time, made several modifications in his apparatus: 1. He proposed heating the whole length of the inner tube by making the outer one long enough to enter the mercury in the trough, and provided for the escape of the condensed liquid and excess of steam by having a small side-tube affixed a short distance above the level of the mercury. 2. Finding that graduated tubes were very liable to crack, he pro-

[1] *Ann. Chim. Phys.* [3], 63, 53. [2] *Wien. Sitz. Ber.* 53 [2], 92.
[3] *Liebig's Ann.*, 141, 273 (1867); *Phil. Mag.*, 34, 1 (1867).
[4] *Ann. Chim. Phys.*, 68, 428.
[5] *Ibid.* [3], 58, 257; "Watts' Dict. Chem.," 5. 373; *Compt. Rend.*, 45, 821; 49, 239.
[6] *Proc. Roy. Soc.*, 21. 203 (1873). [7] "Watts' Dict. Chem.," 5. 374.
[8] *Deut. Chem. Ges. Ber.*, 11, 1196 (1878); *Journ. Chem. Soc.*, December, 1878, p. 937. [9] "Cours de Chim.," 4, 71.
[10] *Liebig's Ann.*, 187, 341 (1877); *Journ. Chem. Soc.*, 1877, vol. ii., 697.
[11] *Deut. Chem. Ges. Ber.*, 11, 1355; *Journ. Chem. Soc.*, January, 1879, p. 63. [12] *Phil. Trans.*, 1857, 460. [13] *Compt. Rend.*, 56, 891.
[14] *Trans. Roy. Soc. Edin.*, 22 [3], 441 (1861); *Ann. Chem. Pharm.*, 121, 101(1862); 122, 247 (1862). [15] *Ibid.*, 98, 301 (1856).
[16] "Williams' Chem. Manip.," 542 (1857).

[1] *Ann. Chim. Phys.* [3], 63, 51 (1861).
[2] "Watts' Dict. Chem.," 5. 367.
[3] *Fresenius' Zeit. Anal. Chem.*, 1. 321 (1862).
[4] *Wien. Sitz. Ber.*, 53 [2], 92 (1866).
[5] *Compt. Rend.*, 78, 496 (1874); *Journ. Chem. Soc.*, 12, N.S., 648 (1874).
[6] *Compt. Rend.*, 78, 534. [7] *Deut. Chem. Ges. Ber.*, 1, 198 (1868).
[8] *Ibid.*, 3, 166 (1870); *Journ. Chem. Soc.*, 1870, 324; 1877, vol. i. 33.
[9] *Deut. Chem. Ges. Ber.*, 8, 1437 (1875).
[10] *Ibid.*, 9, 1419 (1876); *Journ. Chem. Soc.*, 1877, vol. i., 269.
[11] *Deut. Chem. Ges. Ber.*, 9, 1304 (1876); *Journ. Chem. Soc.*, 1877, vol. i., 33.

posed using plain ones in the following manner:—In the bottom of the mercurial trough he placed a piece of sheet india-rubber attached to an iron plate, and provided with a groove on its upper surface; the iron plate was furnished with a handle. During the heating the inner tube stood over the groove to allow of the escape of the mercury. When the level became stationary communication with the mercury in the trough was cut off by shifting the india-rubber disk until the inner tube rested on the flat surface. The height of the column in the inner tube was then noted by means of a cathetometer; the outer tube was then removed and a gummed label attached to the inner one to indicate the mercury level. After cooling, the volume of the vapour is determined from direct measurement. (3) In order to avoid the cracking of the tubes in cases where liquids of high boiling-point were used, he proposed connecting the lower end of the outer tube with the inner one by a cork through which two tubes leading to the flask or boiler passed. One of them led below the liquid, while the other, which was provided with a stop-cock, reached only just below the cork. If this stop-cock be closed while the liquid is being heated, a portion of it is forced up the space between the two glass tubes, and thus the mercurial column is heated more gradually. When the liquid reaches the boiling-point the stop-cock is opened, and the circulation of the steam proceeds as usual. The upper part of the outer tube must be sufficiently elongated or provided with a small tube leading to a condenser.

Brühl [1] proposed working the Hofmann method at a very low pressure by employing a tube 1·5 metres long, with only a small quantity of substance, and was therefore able to make determinations at temperatures far below its boiling-point. He also made the following suggestions:—

1. In order to eliminate the troublesome element of the tension of mercury vapour (without using two tubes as Grabowski did), heat the column to the required temperature, note its height, then allow it to cool, introduce the substance and heat again to the *same* temperature till the height is constant. To ensure uniformity of level in the bulb, keep it full to overflowing.

2. Before the first reading of the mercurial column a small piece of thin glass is passed up to liberate any air that may be contained in the mercury.

3. To make a mark on the tube a little above the vacuum mercury level and then only to calibrate about 150 mm. down from that point; then, to find the total volume, add the variable volume below the mark to the fixed volume above the mark.

Muir and Suguira,[2] in 1877, finding that sometimes the weight of the inner tube caused the groove in the india-rubber disk to so far close as to prevent the escape of the mercury while heating the substance, used a plain india-rubber disk which was fastened to the bottom of the trough, a disk of cork intervening. Communication between the mercury in the tube, and that in the trough was maintained by means of a short piece of glass tubing bent at right angles. A second tube long enough to stand slightly above the level of the mercury in the trough served to carry off, from the space between the two tubes, the condensed liquid and excess of vapour. They adopted Hofmann's original method of passing the steam in at the top of the outer tube, but used a small tube passing through a perforated cork in preference to one fused to the end.

Brühl [3] has, this year, proved by most carefully conducted experiments that the Hofmann method cannot be used above 220° owing to the great and rapidly increasing vapour-tension of mercury, but has omitted the grave objection to his own method. Playfair and Wanklyn [4] called attention, in 1861, to the fact that Bineau,[5] in 1846, pointed out that in vapour-density methods at very reduced pressures slight errors in the readings of the mercurial level introduce very serious errors into the result; this remark also applies to Croullebois.

In the overflow methods, which are in reality modifications of the Gay-Lussac, seeing that they are performed with known weights of substance, the first name is Hofmann,[6] who, in 1860, gave a very meagre description of his apparatus, when he wrote that he used a U-tube heated in a paraffin bath, and estimated

[1] *Deut. Chem. Ges. Ber.*, 9, 1368 (1876); *Journ. Chem. Soc.*, 1877, vol. i., 165; *Moniteur scientif.*, January, 1878, 14.
[2] *Journ. Chem. Soc.*, 1877, vol. ii., 140.
[3] *Deut. Chem. Ges. Ber.*, 12, 197 (1879); *Journ. Chem. Soc.*, 1879, abst., 499.
[4] *Trans. Roy. Soc. Edin.*, 22 [3], 441 (1861).
[5] *Ann. Chim. Phys.* [3], 18, 236.
[6] *Phil. Trans.*, 150, 414 (1860); *Ann. Chem. Pharm.*, Supp., 1, 10 (1861).

the volume of the vapour by the mercury expelled. Wertheim,[1] in 1862–64, in his papers on Coniin, gave very full details of his method, in which he used two tubes suspended side by side in a flask.

Watts,[2] in 1867, employed a globe with a ground neck, into which an outlet-tube reaching nearly to the bottom of the globe was accurately fitted. The globe being filled with mercury and the substance introduced, the quantity of mercury expelled on heating served as a basis for calculating the volume occupied by the vapour. Victor Meyer,[3] in 1876, introduced two very important alterations, he avoided the vapour-tension of mercury by using fusible metal and placed the outlet at the bottom of the bulb. His experiments at that time were all made in the vapour of boiling sulphur, but Graebe,[4] last year, wishing to employ a higher temperature, used phosphorus pentasulphide, which boils at 530°.

Frerichs,[5] in 1876, used mercury in an apparatus similar in principle to that of Watts's, but employed an inverted flask, and brought the exit-tube, which was furnished with an inverted syphon, through a suitable outlet in the bottom of the bath.

Goldschmiedt and Ciamician,[6] in 1877, used mercury with the simpler bulb of Victor Meyer, but added a small side-tube to the outlet, so that the mercury expelled could be weighed from time to time during the heating. Victor Meyer,[7] in the same year, modified the shape of the bulb, but heated it in a tube similar to that employed by Greville Williams in Gay-Lussac's determinations, but of sufficient length for the upper part of the tube to serve as condenser.

Pfaundler's method,[8] of which a preliminary notice appeared in 1870, but which was not brought prominently forward till this year, is based on the increased tension of the air in an elongated bulb produced by heating after the introduction of the substance as compared with a similar determination on air in a bulb of the same size. A very short description appeared in 1874 of a method devised by Dulong [9] which is based on the same principle.

Last year Hofmann [10] proposed two methods; in one of these he heated the weighed substance over mercury in the closed limb of a U-tube, and marked the level of the mercury in the open limb by sliding a pointed tube through a loosely fitting perforated cork until it touched the surface. When the apparatus was cool, the volume of the vapour was calculated from the weight of mercury required to restore the level to that same point. The other consisted in introducing into a tube a small but weighed quantity of substance, then exhausting it and sealing it, and heating in a jacketed tube. At the required temperature the point of the glass tube is opened to allow air to enter, and then at once sealed again. After cooling, the point is opened under mercury or water, and the volume occupied by the vapour is measured.

In Meyer's [11] method, which is so recent and well-known as not to require any explanation, the principle is that of Pfaundler's, but by having the neck elongated and the outlet as a side-tube, the substance is introduced *after* the bulb is heated to the required temperature, and by allowing the air expelled by the vapour free egress into a graduated tube, it can be measured under atmospheric conditions. It is, therefore, so simple that the operation only requires a very short time from first to last.

Dewar and Scott [12] have lately determined the vapour-densities of potassium and sodium in a modified form of Meyer's apparatus.

In this sketch I have purposely kept off the very enticing ground of *formulæ*, as they of themselves open up so wide a field that they could not be dove-tailed into the history of the subject, which from *any* point of view is interesting.

[1] *Ann. Chem. Pharm.*, 123, 173 (1862); 127, 81 (1863); 130, 269 (1864).
[2] *Laboratory*, 1, 225 (1867); *Jahresbericht*, 1867, 31.
[3] *Deut. Chem. Ges. Ber.*, 9, 1216 (1876); *Monit. scientif.*, January, 1878, 7.
[4] *Deut. Chem. Ges. Ber.*, 11, 1646 (1878): *Journ. Chem. Soc.*, March, 1879, 260.
[5] *Ann. Chem. Pharm.*, 185, 199 (1877).
[6] *Deut. Chem. Ges. Ber.*, 10, 641 (1877); *Monit. scientif.*, January, 1878, 13.
[7] *Deut. Chem. Ges. Ber.*, 10, 2068 (1877).
[8] *Ibid.*, 3, 825 (1870); 12, 165 (1879); *Journ. Chem. Soc.*, 1879, abst., 499.
[9] *Compt. Rend.*, 78, 536 1874)); *Journ. Chem. Soc.*, 12, N.S. 650 (1874).
[10] *Deut. Chem. Ges. Ber.*, 11, 1634 (1878); *Journ. Chem. Soc.*, March, 1879, 196.
[11] *Deut. Chem. Ges. Ber.*, 11, 1867 (1878); 11, 2253 (1878); *Chemical News*, February 14, 1879; *Deut. Chem. Ges. Ber.*, 12, 609 (1879); 12, 1112 (1879).
[12] *Proc Roy. Soc.*, 29, 206 (1879).

ELECTRICITY AS A MOTIVE POWER[1]

THE lecturer commenced by referring to the stagnation of trade, to the various remedies that had been proposed to relieve it, and to the fact that while some were maintaining and others stoutly denying that commercial depression could be cured by legislation, we were too apt to forget that there existed a means by which, without lessening the wage of the workman or the profit of the master, the cost of production could be diminished, prices lowered, and the failing trade of England resuscitated. He next considered the consumption of coal for various purposes yearly in Sheffield, and showed that, although the price of coal in that town was very low, being only five shillings per ton for steam coal, the total annual cost for Sheffield alone must be something like 790,000*l.* Actual instances were then given of great saving being effected by water-power being employed on a large scale for doing mechanical work. Contrasted with this, calculation showed that at the Falls of Niagara as much power was wasted as could be produced by the total present annual consumption of coal throughout the whole world. And when it was remembered that there existed in the world other waterfalls besides Niagara, that we had also innumerable rapidly-flowing rivers, the important fact, well known to scientific men, but one which it was so difficult to induce the world at large to grasp, stared us in the face—that we obtained in a laborious way from the depths of the earth the power we employed, and we let run to waste, every hour of our lives, many, many times as much as we used.

Again, even in a perfectly flat country, where waterfalls were unknown, the question of the economic transmission of energy had no less interest, for large steam-engines could be worked much more economically than small ones, large steam-engines requiring a consumption of only two, or two and a half, pounds, of coal per horse-power per hour, whereas small steam-engines burned eight or ten pounds, or even more. And even where large economical engines were employed there was often, as in the gigantic cotton-spinning mills in Manchester, an enormous waste of power in the shafting used in transmitting it from the engine at the base of the factory to all the different floors, and parts of each floor, a waste so great that, in spite of the extreme inefficiency of small engines, it had been proposed, as an economical measure, to replace the one large steam-engine by many small ones, each driving two or three machines direct.

The lecturer then proved numerically that (contrary to the views expressed by some people) it was impossible to use economically in a town, for motive power, the water already brought in pipes to the houses for drinking purposes, since in most towns power so produced would cost about one shilling per horse-power per hour, and although in Sheffield the great head of the water would diminish this to about fivepence per horse-power per hour, still this had to be compared with considerably less than one farthing per hour the low cost in Sheffield of producing each horse-power with a very *large good* steam-engine.

Experience was leading us to see that it was to electricity that we must resort to obtain a carrier that would, at a small cost, transport our motive power over long distances, and as an illustration that the electric transference of energy on a large enough scale to be of practicable value was possible, knives were ground on the platform by power conveyed about a quarter of a mile through wires carried over the houses, a Siemens's dynamo machine being employed at the one end to convert into electricity the motive power supplied by a steam-engine, and a similar but smaller Siemens's dynamo machine being used on the platform at the other end to reconvert into motive power the electric current conveyed by the wires.

The principles on which dynamo-electric machines and electro-motors act were then entered into fully experimentally, and reference was made to the first electro-motor ever made—that constructed by Salvator del Negro in 1831—as well as to the improvements introduced into it by Jacobi, who replaced the oscillating motion by a rotatory one; different forms of modern electro-motors were then shown in action driving sewing-machines, &c. It was mentioned that although Jacobi abandoned his electro-motor used to propel a boat on the Neva because the fuel cost too much, still, that the subject of electro-motors was none the less practically important because we had since learnt why the old form was such an expensive producer of power, and what was the proper duty to be performed by electro-motors.

[1] Abstract (by the author) of the British Association lecture delivered to 4,000 of the working-men of Sheffield, August 23, 1879, by Prof. W. E. Ayrton.

It was this very question :—Can an electric engine be made to work more economically than a steam engine? that first attracted Joule, of Manchester, in 1843, to commence that all-important investigation, which lasted for six years, the determination of the mechanical equivalent of heat.

Formerly, electric currents were almost entirely produced by galvanic batteries, in which zinc was burnt just as in the furnace of a steam engine coke was burnt. The amount of heat that could be got from burning a pound of zinc could be ascertained in the same way as the amount of heat produced by the burning of a pound of coal, but the fact that the latter was about seven times the former was of little value in the science of electro-motors, until Joule had proved that a certain quantity of heat was always equivalent to exactly the same quantity of work, no matter how the heat be produced; had proved in fact that energy was as indestructible as matter, a law which had for one of its proofs the long unsuccessful search for a perpetual motion.

As a result of this law of the conservation of energy Prof. Ayrton went on to show that since a pound of ordinary coal burning gave out seven times as much heat as the burning of a pound of zinc, we might say at once, that a steam engine would give seven times as much work as an electric engine for equal weights consumed, if in both cases all the heat could be turned into work; or, since zinc was about twenty-four times as dear as coal, that a steam engine would be about 150 times as economical as an electro motor, worked by a battery, if in both cases all the heat were converted into work.

But so far, he said, "we have only considered the law of 'Conservation of Energy.' There is, however, another, and no less important, principle called the 'Dissipation of Energy;' and this law tells us that although the energy of a system cannot by itself increase or diminish, yet our power to convert one form of energy into another is continually growing less, our stock of available energy is gradually failing. Our mountain lakes, our vast store of coal, are practically useless until either the water is set in motion rolling down the hillside, or until the particles of the coal are set in rapid vibration as it slowly burns; energy of position, energy of chemical affinity, are of no use to the manufacturer until turned into kinetic energy or energy of motion. But from friction of various kinds, whenever energy exists in the kinetic form, some portion of it is being continually converted into heat. Whenever man or nature utilises energy it must be first turned into some kinetic form, and whatever be the aim of the special machinery employed some of this energy passes into heat. We cannot make even a clock go without regular winding up, although the only useful work done by the clock is to turn its hands at regular speeds; the earth's energy of rotation is now, like the moon's in past ages, gradually growing less, and is being converted into heat on account of tidal retardation; the earth, moon, and sun, and all the planets are losing their energies of motion and relative positions, to be all ultimately turned into heat.

"But at any rate, it will be said, there will still remain the heat, and since heat can be converted back into other forms of energy, we shall be none the worse off. But it must not be forgotten that whenever heat is produced some passes off by conduction through even our best non-conducting substances, and by radiation into space from even our best non-radiating surfaces; and this conducted and radiated heat, although it may impart some trifling warmth to unseen worlds, is for the greater part entirely lost to our universe. And even were it not so, even had we perfectly non-conducting coatings, and perfectly non-radiating surfaces—had we, in fact, the most perfect heat engine that our study of the science of heat would lead us to believe theoretically possible, one with no friction, no loss of heat by conduction through the sides of our cylinders, and no radiation from their surfaces—still our power to convert heat into other forms of energy would be very limited. For if there are two bodies, one hotter than the other, we can employ an engine, like a steam-engine, to convert part of the heat in the hotter one into some other form of energy; but the amount of heat converted, with even this ideal perfect engine, will, with such temperatures as are met with in practice, only be a fraction of what necessarily passes through the engine from the hot body to the cold, and warms up the latter; and as our whole power of conversion of heat into work depends on the difference of temperature, we lose it altogether when we have brought all parts of a system to the same temperature, no matter how high this temperature may be.

"It is not, therefore sufficient to say that the burning of a pound of coal produces seven times as much heat as the burning of a

pound of zinc; but we must consider what fraction of the heat thus produced is converted into useful work in a heat and in an electric engine respectively.

"As already mentioned, our most perfect steam-engines can be made to produce one-horse power with the consumption of 2 lbs. of coal per hour. Now, the burning of 2 lbs. of coal will produce enough energy to raise 18,528,000 pounds one foot, or will produce 18,528,000 foot pounds of work. Now, one-horse power is equivalent to 1,980,000 foot pounds of work per hour; therefore, as regards the total energy in coal, even our best steam-engines only utilise $\frac{2}{9}$ of it, and waste $\frac{7}{9}$. But, as already mentioned, even a perfect engine cannot, with the ordinary temperature available, utilise the whole of the heat of the fuel. In fact, theory tells us that the efficiency of a perfect heat engine, or the ratio of the work done to the maximum work obtainable from the consumption of the fuel, is equal to the ratio of the number of degrees of temperature through which the steam is cooled in doing work to the highest temperature of our steam, when we take as our zero of temperature a point 460° below the ordinary zero of the Fahrenheit scale.

"Now, in our best steam-engines, the steam, when it begins to push the piston by expanding, has a temperature of about 300° F., and at the end of the stroke a temperature of 100° F., so that the efficiency of a perfect ideal engine working between these temperatures is only about $\frac{1}{4}$, not so very much greater than that of best practical engines.

"No great advance can be made, then, in a heat engine, except by making the temperature of the working substance, steam, gas, or whatever it may be, much higher. If, for example, we could raise the temperature of the working substance as high as, say, 3,000° F., the temperature of combustion, and could make it leave the engine without artificial cooling at the ordinary temperature of the air, which is, say, 60° F., then a perfect heat engine, under these conditions, would only waste about $\frac{1}{7}$ of the total energy; consequently, assuming that we could, at these high temperatures, make a practical engine as good relatively to an ideal perfect engine as we can at lower temperatures, then a practical engine would only waste $\frac{7}{45}$ of the total energy, or would have an efficiency of about 0·84.

"But, with our present knowledge, to work with steam or gas at a temperature of 3,000° F. is almost as ideal as an engine with no friction and with no loss of heat by conduction and radiation. We are, therefore, led to the conviction that as it is solely by working with steam at very high temperatures that the efficiency of steam-engines can be seriously increased, it may be well to consider whether it is not possible to economically replace the steam-engine with some other form of motor."

It was then proved theoretically and experimentally that whenever an electro-motor is being worked by an electric current it is acting as a magneto-electric machine and producing a reverse current tending to stop the motion.

The lecturer then explained that, when an electro-motor is worked by a *given* galvanic battery, calculations lead us to the result that if we wish to produce the work *most economically* we must, by diminishing the load on the motor, allow its speed to increase until the reverse current it produces is only a little smaller than that sent by the battery; in fact, until the current circulating through the arrangement is very small, in which case the efficiency of the engine, or the ratio of the work it produces in a given time to the maximum work it could produce from the same consumption of material is nearly unity. If, on the other hand, we desire a *given* battery to cause the motor to do work *most quickly*, independently of the consumption of material, then calculation tells us that we ought to put such a load on the motor that its speed will send a reverse current equal to something like a half of the strength of the current the battery could send through the motor when at rest. In this case the efficiency is about $\frac{1}{2}$, or half the energy is wasted in heat.

He impressed upon the audience that the difference between these two considerations of maximum values ought carefully to be borne in mind, especially as it was usually the second—or how to obtain work *most quickly*—that had generally been taken into account, whereas it was the other one—or how to transmit work *most economically*, that would specially engage their attention during the lecture.

And in connection with the latter maximum value he said, "Let us consider that we work our motor in the most efficient way—that is very fast with a small load, and let us suppose as an extreme case that by so doing the efficiency is so little short of unity that we may regard it as one; then since an electro-motor worked by a battery in which zinc is burnt is 150 times as costly to maintain as a steam engine for equal efficiencies, the best electromotor worked by such a battery will be thirty-three times as dear as our best steam engines having an efficiency of $\frac{2}{9}$. We may, therefore, throw on one side at once all idea of electro-motors worked by ordinary batteries, even although the electro-motors be perfect. Now, this result is most important, since it shows not that an electro-motor as a machine is inefficient, but it tells us that attempting to drive it with a galvanic battery is the hopelessly inefficient part of the arrangement.

"But if we turn to the question of using electro-motors for the transference of power, then there is no difficulty about burning zinc, and the high efficiency of such motors is all important.

"For in the case of natural sources of power, such as waterfalls, we have merely to consider what amount of energy will be produced at the distant factory; will it be sufficient to repay the expense of putting up wires from the source to the factory, together with the cost of the two dynamo-electric machines, or will it be cheaper to put up and use a small steam engine having probably an efficiency of only $\frac{1}{18}$?

"When the distance between the source and the motor is considerable, the cost of putting up the leading wires becomes important, and the question therefore arises, can two or more people use the same leading wires without increasing the thickness, or must the thickness of the wire be so much increased as to make the construction of two sets of leads as economical?"

Prof. Ayrton explained that he attached great importance to this question because the answer to it would decide whether the electric transmission of power was a mere dreamer's fancy, or was likely to have a real commercial future.

A detailed examination was then made of the laws governing the transmission of energy by water power, and as a result of the fact that the energy of a flow of water depends on the quantity and on its head it was shown that, as far as the waste of power by friction of the water in the pipes was concerned, a great pressure in the reservoir sending a small current to turbines in a town also working at great pressure was an extremely economical mode of transporting power, but that if we took into account the inefficiency of existing engines for producing a great pressure of water at the reservoir, combined with the great waste of power arising from even small leakages that were certain to be caused by the great water pressure, it followed that the system was an impracticable one.

An examination was then made of the laws governing the electric transport of energy, and the lecturer arrived at this result:—

"Just as we concluded in the case of the water, that the most efficient method to employ in order to transfer the energy, was great pressure in the reservoir, combined with turbines in the town working at a high pressure, so now we conclude that the most efficient way to transfer energy electrically is to use a generator producing a high electromotive force, and a motor producing a return high electromotive force; and by so doing the waste of power in the transmission ought, I consider, be able to be diminished with our best existing dynamo-electric machines to about 30 per cent.; for, as experiment shows the efficiency of our best existing dynamo-machines to be 0·86 (that is 86 per cent. of the power spent in revolving the bobbins is reproduced as energy of electric current); therefore, if two similar dynamo-electric machines be coupled up to transmit power, and if they are worked most *economically* in the general way I have already explained, and with the details of arrangement that I will enter into later on, instead of being worked so that the motor gives out power *most rapidly*, I have reason for expecting that the combined efficiency of the arrangement can be made to closely approach the square of 0·86, and not merely one-half, as commonly supposed.

"But while the two solutions of the problem are thus identical, there is this most important difference: increasing the pressure of the water means an uneconomical task, while increasing the electromotive force set up by a dynamo-electric machine, or an electro-motor, means merely running it faster, or running it at the same speed and putting more wire on the rotatory portion.

"And again, assuming that the mean electromotive force between the wire and the earth be as much as one hundred times the electromotive force producing the current, namely, the difference between the electromotive forces of the generator and of the motor, then with the ordinary insulation of the best land telegraph lines, less than one per cent. of the energy transmitted ten miles would be lost by leakage.

"It would be impossible to increase indefinitely the speed of revolution of the cylinder of an induction machine, since apart from mere mechanical friction the iron constituting the core of the revolving part has to be magnetised and demagnetised very rapidly as it revolves. Now, there is a physical limit to the speed with which this can be done, and in addition this rapid change of magnetism heats the iron very much. But experiment shows that at the ordinary speed of revolution of dynamo-electro machines, 700 turns per minute, the electromotive force is proportional to the speed. We are, therefore, very far yet from the limit of speed. Consequently it would be well for the transmission of power to attempt first, a considerable increase of speed in the generator, combined with so light a load on the motor, that its speed is also very high. When this begins to fail as larger and larger amounts of power are transmitted, then we might begin increasing the amount of wire on the revolving coils of each; but this, of course, has the objection that the loss of power from a given current would then become somewhat larger.

"In some of the dynamo-electric machines, the current that is sent through the external wires is the same as that which circulates round the fixed electro-magnets to create the magnetic field in which the movable coils revolve. Now, the small current which I am here advocating should pass between the generator at the one end of the line, and the electro-motor at the other, would be too small to properly magnetise the fixed electro-magnets of the two machines, so that even a high speed of the bobbin will not produce a high electromotive force. But this difficulty is easily overcome by the plan already employed, for totally different reasons, by Gramme, Lontin and Wilde, in their generator for producing currents for electric lighting, viz., that of using either a separate exciter, or a separate portion of the revolving bobbin in the generator, to produce the current to magnetise the fixed electro-magnets. In connection with this current for exciting the fixed magnets, it is worthy of notice in passing, to observe that since experience shows that the electromotive force of a dynamo-electric machine is proportional to the velocity, I conclude that the magnets are saturated, and that the exciting current is already too strong, so that it may be with advantage reduced, or many fewer coils of wire employed in this portion of the machine.

"We have then been led to this most important result which I hope is clear to you all, and which I trust you may all carry away with you—*that a dynamo-electric machine, with a separate exciter, driven very fast with a steam engine, or with a stream of water, at high or low pressure, and sending, by even quite a fine wire, a small current to a distant electro-motor, also running very fast and magnetised by a separate exciter, is an economic arrangement for the transmission of power.*"

An examination was then made of the way this result was affected by increasing the length of the connecting wires, and it was proved that the electric transmission of power was not only practical, but also very economical, both for short and long distances, if the generator of the electric current at one end of the line and the motor, worked by this electric current, at the other end of the line, were both run fast enough, and if only we required to transmit a sufficiently large quantity of power.

The lecturer then went on to say, "We have been considering the transport of power derived more especially from natural sources; but since we have seen that by the use of electricity, properly employed, the waste of power in transmission can be reduced for any distance to about 30 per cent. of the whole power absorbed at the generator, it follows that the employment of steam-engines of vast size at points outside Sheffield would be by far the most economical mode of extracting the energy out of coal. For it is at least four times as expensive to produce power with a small steam-engine as with a large one; therefore, including the waste of power in electric transmission, the cost of production of power in small workshops would be little more than one-third as dear as if small steam-engines were used, and similarly the waste of power in any large mill or factory in its transmission from the large steam-engine at its base to all the floors and machines on each floor would be very much diminished.

"Consequently it would be much more economical to work this lathe on the platform, as I will now proceed to do, by a big steam-engine in Howard-street, several hundred yards away, than to use a small steam-engine here for this purpose."

He then reminded them that not only can electricity produce motive power, but also light and heat, and electric heating and lighting had this great advantage, that no chimneys were required. Experiments were then made of boiling water and lighting the Albert Hall by an electric current generated a quarter of a mile away.

Reference was then made to the great money-saving of something like 30*s.* an hour, that Dr. Siemens had been able to effect at the Albert Hall, London, by replacing the old gas jets by electric lamps giving even more light, and to the unexpected advantage attained by the present stillness of the air arising from the use of the electric light, and which enabled the singing and music there to be better heard now. Great weight was attached to the fact that at the Albert Hall the science of hanging a brilliant light high up had been luckily allowed to ride over the precedent of putting a number of feeble glimmers all over a building, and in connection with this it was explained that the reason why electric lighting for streets had been economically much less successful, was because English conservatism had prevented the authorities from realising the possibility of using for street electric illumination anything differing from an ordinary iron lamp-post. Attention was then drawn to the fact bearing most closely on the economy of electric lighting on a large scale, and which had been obtained as the result of experiments, that the larger were the dynamo machines used for producing the electric light, the more light was produced per horse-power. Taking all this into consideration, Prof. Ayrton arrived at the result that "at any rate we may be absolutely safe in saying that the cost of using gas in Sheffield for lighting large halls, such as the one we are now in, factories, and the streets could be halved if electric currents, generated by water engines worked by hill streams, as well as by very large steam engines, were substituted for gas.

"But can this be quite right, for I have proved that to transfer energy economically we must use a large pressure and a small flow. Now, how can we produce a very bright electric light with a small current? Why, by not using the current that comes along the wire to produce the light at all, but merely to drive an electro-motor, which motor, at the place where any large amount of light was required, would be employed in giving motion to a second dynamo-electric machine, which would produce the currents for lighting purposes.

"This experiment I might show you, but as we have used already several times during the evening electric lights fed from a distance, we will vary the experiment and try an analogous one. Messrs. Walker and Hall will now, at their works, give rapid motion to a dynamo-machine, and the current which, when properly arranged, as I have explained to you, may be small, will set in motion this electro-motor. This in its turn will cause this other dynamo machine to rotate rapidly and produce a current which I will use for rapidly gilding this piece of plate."

Calculation showed that if electric currents generated by very large steam engines at certain points, and by turbines driven by the falling water on the hillsides round Sheffield, were substituted for the use of coal for motive power, smelting, heating, and lighting buildings, that a saving of something like 400,000*l.* a year might be anticipated for that town; and as an argument to prove that although such a reform was startling in its economical bearing, it might nevertheless be sound, the following was adduced:—Imagine the cost of cutlery and plated goods to remain as at present, but all machinery to be removed from Sheffield, then what an enormous loss would accrue to the town from everything having to be done by hand labour. The saving then which the lecturer was showing the audience how to obtain, enormous though it might be, was still small compared with the gain that the introduction of machinery during the last hundred years had effected for that town.

Next was considered whether the Sheffield Water Company had any water in their reservoirs that could be spared for producing motive power, since of course the water which did work at its source would lose head and so be unable to come to the tops of the houses in the town as at present, and it was shown that there was a considerable surplus supply. As an illustration of such a use of the water power, a two inch board was sawn on the platform by a circular saw, driven by an electric current generated by a water engine in the yard of the Water Works, and conveyed to the Hall by wires crossing the streets.

As a practical illustration of what had been done the lecturer said:—"Last year two French engineers, MM. Chrétien and Felix, at Sermaize (Marne), actually ploughed fields by electricity, the electric current being produced by two dynamo-electric machines, of a form invented by M. Gramme, and shown in the diagrams on the walls. These machines were usually worked

with a steam engine at some convenient place three or four hundred yards away in an adjoining road, and the electro-motors were also two Gramme machines, one on each side of the field, with their coils revolving of course backwards. Through one of these, the electric current was sent alternately, so that motion was given to one or other of two large windlasses, one on each of the waggons containing the electro-motors. In this way the plough, which could be used going in either direction, was first pulled across the field making a furrow, and then back again making another parallel furrow."

A photograph taken on the spot, of one of the complete Gramme electro-motors, with its windlass and waggon, together with the double acting plough, was projected on to the screen.

A second photograph was also now projected on to the screen of M. Chrétien's electric crane for unloading boats. This too, the lecturer said, had been successfully employed for several months at Sermaize, in the harbour there, and it was considered that a saving of about thirty per cent. had been effected of the expense formerly incurred for unloading the sugar barrels out of the boats.

Reference was then made to the difficulty that would be experienced in distributing electric power properly on account of the current in any curcuit being affected by any alteration in any other circuit connected with it, and it was explained how this difficulty was met by the electric current regulations of M. Hospitalier and Dr. Siemens. Another difficulty arising from the velocity of the water on the hill streams being great after floods and small in dry weather, and which at first sight might appear to require an extravagant supply of dynamo machines so that even in a draught sufficient power could be transmittted electrically, it was explained, could be overcome by storing up the electric energy as compressed gas, and it was shown that a square foot of hydrogen at thirty atmospheres pressure (the usual pressure in the iron gas bottles of commerce) combining with half a cubic foot of oxygen, at the same pressure, would develop no less than 110 million foot pounds of work.

Prof. Ayrton concluded by asking:—

"But is there no other side to this question? We are, it is true, a commercial people, but do we not still love our hills and our fields? There was a time when the cutler of now black, grimy, Sheffield was very fleet of foot in following the chase. There was a time when 'Not only in the villages around old Sheffield,' so says the history of Hallamshire, 'were the file-makers' shops or the smithy to be seen, with the apprentices at work; but even on the hill side in the open country, at the end of the barn would be the cutlers' shed whilst in the valley below, by the river, was the grinding wheel ready to sharpen the tools that had been manufactured.'

"And why not now? why should not that mountain air that has given you workmen of Hallamshire in past times your sinew, your independence of character, blow over your grindstone now? Why should not division of labour be carried to its end and power brought to you instead of you to the power? Let us hope then that in the next century electricity may undo whatever harm steam may have done during the last, and that the future workman of Sheffield will, instead of breathing the necessarily impure air of crowded factories, find himself again on the hill side, but with electric energy laid on at his command."

THE ANTIQUITY OF MAN

At the Sheffield meeting of the British Association Prof. Boyd Dawkins, in the course of a paper "On the Antiquity of Man," said he presented before them a diagram showing the divisions of the tertiary period, the third of the three great life periods which had been presented on the earth. When he examined those stages before the highest forms of life, he was confronted with this most important fact: in the eocene age they had not a single species of placental mammal, nor did they meet with any indications of a living placental genus. No species now found in Europe were found in the eocene age. It was absolutely impossible to suppose that man was living on the earth in eocene time, yet there was no reason, because of climate and vegetation, that he should not have been. Then they came to the miocene age, when they found not merely living families and orders, but living genera. Putting man out of the question, there was not a single well-authenticated case on record in any part of the world of any mammalian species now living on the earth having lived in the miocene age. The French preserved a flint flake which was found at Thenay, and which they say is of the miocene age; in fact it was accepted by a great majority of the French archæologists that man was living in the miocene age. The French held that flints found, and all of them bearing traces of manufacture, were of the miocene age, and the work of man. It was far less difficult to believe that these flints were the work of some of the higher and extinct forms of mokeys, than it was to believe that they were the work of man. In the pliocene age they found one or two living species making their appearance. Prof. Capelini had called attention to the fact that certain cut bones, which were asserted to be of the miocene age, had been cut by the hand of man. On one of those bones there were cuts which were done by the hand of man. The cuts were distinctly artificial, but the difficulty which presented itself to his mind was this. He was by no means certain that those bones, which were said to have been found in the pliocene strata, had been discovered in undisturbed pliocene strata. It was not clear to his mind that the mineralisation of those bones would not take place long after the pliocene age had passed away. He urged his objections to the accepting of specimens said to have been got in the pliocene age when there was no good authority for saying that such was the case. He then passed to the pleistocene, by some called the glacial period. Then living species were very abundant, extinct species very rare, and it was in that age that they met with man in considerable abundance and scattered over a very wide area. The evidence presented from time to time, in the first place out of caverns, and on the other hand out of river deposits, showed beyond a doubt that man was present in Europe in full force in the pleistocene age, and he came in just when it might be expected he would come in. In the pleistocene age they met with man as a mere hunter, not as a farmer or possessor of wild animals. He mentioned that because during the last two or three years it had been asserted that man was possessed of domestic animals in the pleistocene period. The pre-historic period which succeeded the pleistocene, was characterised by the absence of the extinct species of mammalia, with one exception. The one extinct animal which extended upward into the pre-historic age was the Irish elk. The great characteristic of the pre-historic age was the calling in of the domestic animals, the dog, sheep, horse, various breeds of hog, cattle—all coming in under the care of man, all spreading over Europe; and along with them they had the getting of cereals and fruits, and the cultivation of the arts of agriculture. They had in that period just those very things which formed the foundation of that civilisation which they themselves spread, and which had been built upon the foundations of the neolithic age. The pre-historic period was divided into the neolithic, the bronze age, and the age of iron. The pre-historic age was divided from the historic, because the former was not represented to them in historic records. In conclusion he ventured to express an opinion as to how happy they would be if they could get hold of a date and fix the antiquity of man in Europe in terms of years. It would be most delightful if they could fix the first presence of man at Creswell Crags, say within some thousands or hundreds of thousands of years. He could not help thinking that all their hopes of that description would be vain, as there were intervals, and they could not know without the written record, the duration of the intervals which separated one period from another.

UNDERGROUND TEMPERATURE[1]

The temperature of the surface of the ground is not sensibly influenced by the flow of heat upwards from below, but is determined by astronomical and atmospheric conditions. The rate of increase in travelling downwards from the surface may conveniently be called the *temperature gradient*, and averages about 1° F. for fifty or sixty feet. This is about five times as steep as the temperature gradient in the air.

If we draw isothermal surfaces for mean annual temperature in the ground, their form beneath mountains and valleys will be flatter than that of the surface above them. This is true even of the uppermost; and the flattening increases as we pass to lower ones, until at a considerable depth they become sensibly horizontal planes. The temperature gradient is consequently steeper beneath gorges and least deep beneath ridges.

In a place where the surface of the ground and the isothermal surfaces beneath it are horizontal the flow of heat will be vertical,

[1] "On some Broad Features of Underground Temperature," by Prof. J. D. Everett, F.R.S. Abstract of paper read at the Sheffield meeting of the British Association.

and the same quantity of heat will flow across all sections which lie in the same vertical. In this case the flow across a horizontal area of unit size will be equal to the product of the *temperature gradient* by the *conductivity*, if we employ the latter term in an extended sense so as to make it include convection by the percolation of water, as well as conduction proper. It follows that in comparing different strata lying in the same vertical, the gradient will vary in the converse ratio of their conductivity. It seems probable that the same law of inverse proportion between gradient and conductivity holds approximately even when the strata compared are not in the same vertical but are widely distant.

As regards the modes of observation which have been employed for the determination of gradients:—shafts full of water, and wells of large diameter, afford so much facility for equalisation of temperature by currents between the colder water above and the warmer water below, that they furnish no useful results. Even in bores of small diameter the same disturbing cause exists and always makes the observed less than the true gradient.

Observations in mines will be vitiated by the presence of pyrites, which generates heat by its slow combustion, and are also liable to be vitiated by strong currents of air; but when they are taken at the newly exposed face of a gallery which is being driven into the rock, care being taken to prevent strong air-currents at the place, and the surrounding ground not being too much honeycombed by previous excavations, good results may be obtained. A hole should be bored to the depth of about two feet in the newly exposed face, the thermometer inserted, and the hole plugged with clay.

SCIENTIFIC SERIALS

American Journal of Science and Arts, September.—In the opening paper, on the pertinacity and predominance of weeds, Prof. Asa Gray, from an examination of European weeds which have taken a strong hold on the United States, opposes Mr. Henslow's view that plants best fitted for domination as weeds are in general self-fertilised plants, and owe their predominance to this. He also regards the "greater plasticity" assumed by Prof. Claypole for European as compared with American plants as purely hypothetical.—In view of the variations in amount of oxygen in the atmosphere of a given place (sometimes by as much as one-fortieth of the average, and often the one-hundredth or two-hundredth part), Prof. Morley calls in the theory by which Prof. Loomis accounts for certain great and sudden depressions of temperature at the earth's surface, viz., by vertical descent of cold air from the higher parts of the atmosphere. The lower air at such times might well contain a less proportion of oxygen than the average. Pending systematic observations at points Prof. Loomis has indicated, the author here describes at length his method of analysis, and the results of observation on samples of air collected at home; these seem to lend some support to his theory.—A remarkable meteorite fell at Estherville, Emmel Co., Iowa, on May 10; one mass weighing 431 lbs. was found fourteen feet under the surface of the ground in a ravine, and, besides several small masses near, a mass of 151 lbs. about two miles westward. Prof. Shepard, from specimens in hand, regards this meteorite as a connecting-link between the litholites and lithosiderites, unless it be placed as a separate order in the Eucritic group of the former.—Prof. Marsh announces the discovery of two new lower jaws belonging to the genus *Dryolestes* (of Jurassic mammals).—Remaining papers:—On the colour correction of achromatic telescopes, by Mr. Harkness.—Reply to Principal Dawson on *Eozöon canadense*, by Prof. Möbius.—Terminal moraines of the North American ice-sheet (continued), by Mr. Upham.—New observations on planetoids, by Mr. Peters.—Observations on the genus Macropis, by Mr. Patton.

SOCIETIES AND ACADEMIES

Paris

Academy of Sciences, September 29.—M. Daubrée in the chair.—The following papers were read:—On the development of the perturbative function in the case where, the eccentricities being small, there is any mutual inclination of the orbits, by M. Tisserand.—Construction of the international geodetic standard, and determination of its controlling weights, by MM. Sainte-Claire Deville and Debray. The method is given in detail.—Studies on the effects and mode of action of substances employed in antiseptic dressings, by MM. Gosselin and Bergeron. The method was to put blood, then pus, in contact with various antiseptic agents (including solutions of carbolic acid of various strength, camphorised alcohol, camphorised brandy), and noting the effects, both with the naked eye and with the microscope. The antiseptic agent was in some cases put in glasses with the blood or pus, sometimes applied by means of evaporation and pulverisation. The result is specified in each case; the 20 per cent. solution of carbolic acid, alcohol, and camphorised alcohol, seem to have prevented putrefaction best.—Theoretical essay on the law of Dulong and Petit; case of solid and liquid bodies and vapours, compound bodies, by M. Willotte.—Vibratory forms of bubbles of glyceric liquid, by M. Decharme. A bubble is supported on a thin watch-glass fixed at the end of a vibrating plate or rod; it follows and amplifies the vibrations, and with favourable conditions one can see distinct nodes and ventral segments, whose number varies with the velocity of vibration and diameter of the bubble. Three laws are given: (1) With a given number of nodals, the diameters of the bubbles are proportional to the lengths of the vibrating plate, or inversely proportional to the square roots of the numbers of vibrations. (2) With a given diameters of bubbles, the numbers of nodals are inversely proportional to the lengths of the vibrating plate, or directly proportional to the square roots of the numbers of vibrations. (3) With a given length of vibrating rod, the numbers of nodals are proportional to the diameters of the bulbs. These experiments generalise that of Melde by extending it to spherical surfaces, and even to volumes, for the author has found that thin balloons of caoutchouc filled with water behave like bubbles.—On the presence of alcohol in the animal tissues during life and after death, in the case of putrefaction, from the physiological and toxicological point of view, by M. Bechamp. Horse-flesh (3 kg.) plunged for ten minutes in boiling water, to coagulate the surface, then inclosed in a vessel, was examined after a month. About 0·8 gr. of alcohol was got from the interior, and 10 gr. of salts (acetate, butyrate, &c.) of soda. (There were numerous bacteria; no vibrion.) 4 kg. left to itself four days gave less alcohol. Thus putrefaction is essentially similar to fermentation; and specially so to butyric. M. Bechamp also found alcohol in various healthy animal tissues (brain, muscles, and liver).—Action of sulphide of carbon liberated in a slow and prolonged way on the vine, by M. Rohart. This is more efficacious than the brief application, and does not injure the plant.—Discovery of two small planets by Mr. Peters.—Action of metallic nitrates on monohydrated nitric acid, by M. Ditte.—Thermal study of succinic acid and its derivatives, by M. Chroustchoff.—On a new curare extracted from only one plant, *Strychnos triplinervia*, by MM. Couty and De Lacerda. This is less active than the other, but easy to obtain in large quantity. It gives in a few seconds a curarisation which may be arrested in its different periods.

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